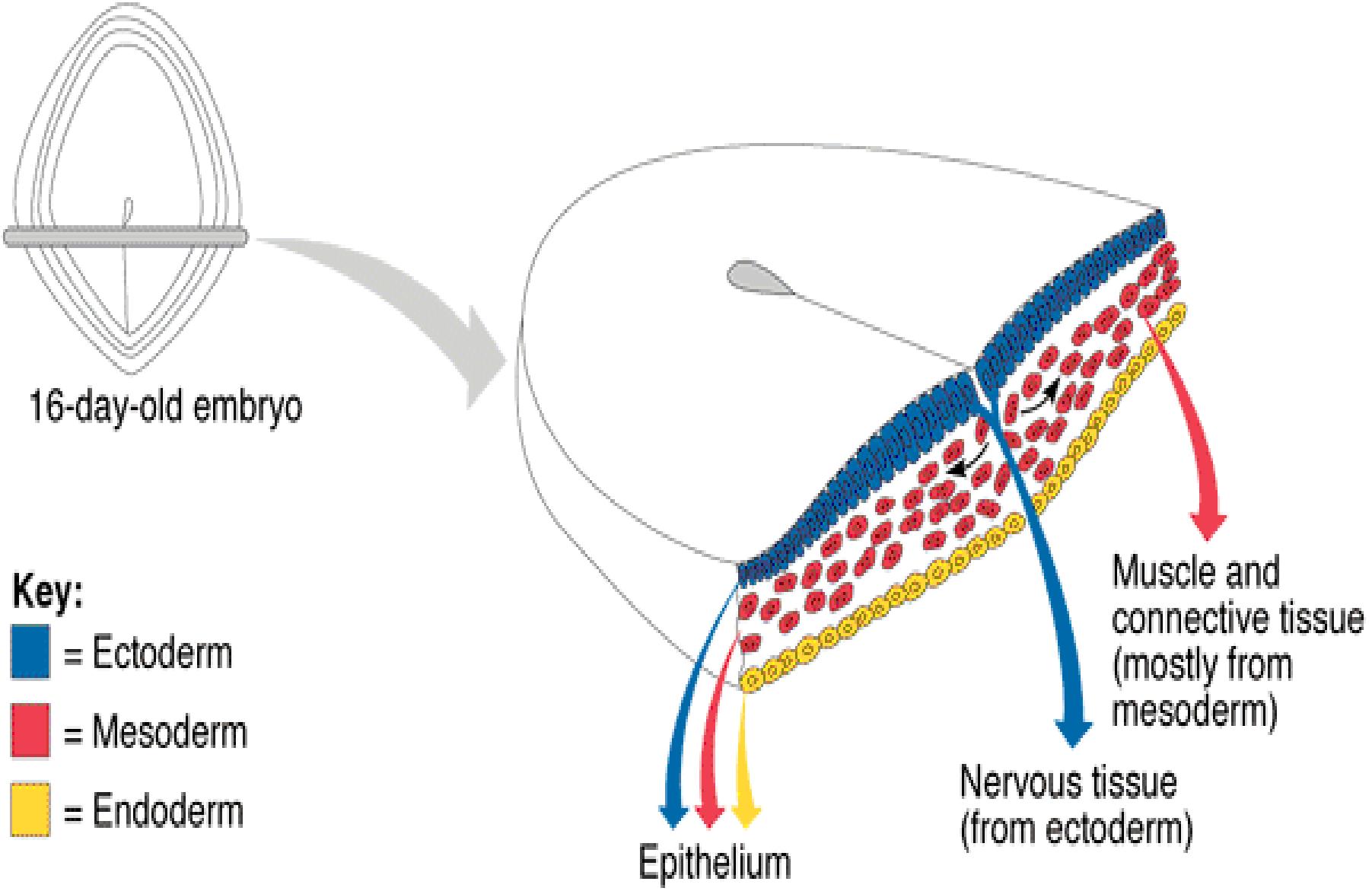
CHAPTER 5

The Integumentary System

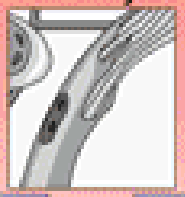
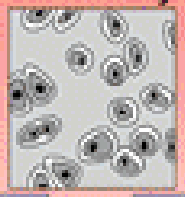
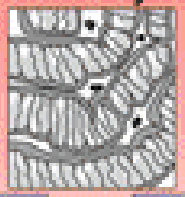
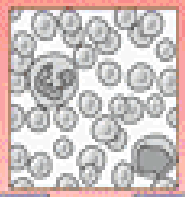
SKIN

Anatomy & Physiology 1



Common embryonic origin: Mesenchyme

Cellular descendants:

Fibroblast	Chondroblast	Osteoblast	Hemocytoblast
Fibrocyte	Chondrocyte	Osteocyte	Blood cells* (and macrophages)
			

Class of connective tissue resulting:

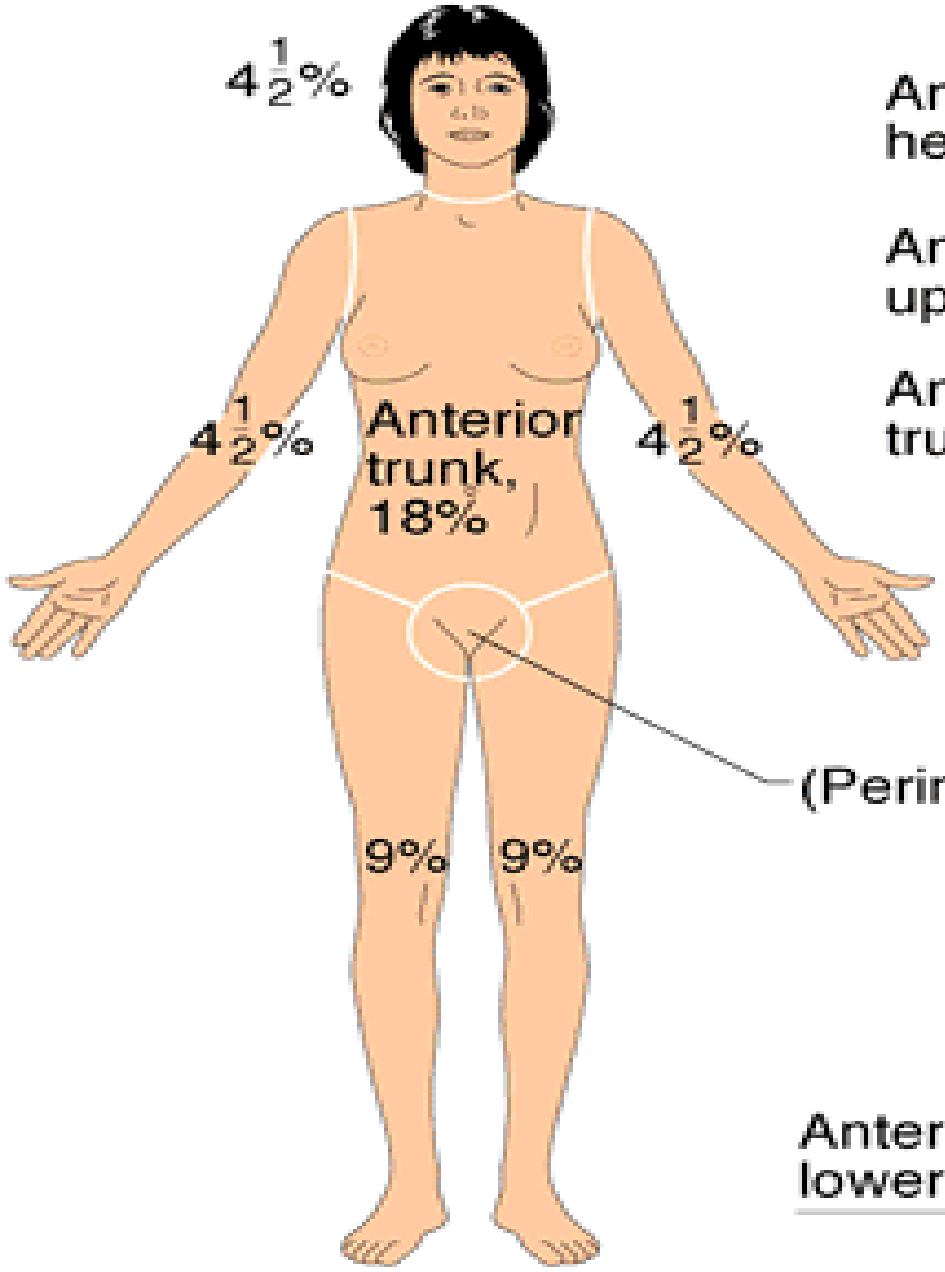
Connective tissue proper	Cartilage	Osseous (bone)	Blood

Subclasses:

1. Loose connective tissue Types: Areolar Adipose Reticular **2.** Dense connective tissue Types: Regular Irregular Elastic	**1.** Hyaline cartilage **2.** Fibrocartilage **3.** Elastic cartilage	**1.** Compact bone **2.** Spongy (cancellous) bone	** Blood cell formation and differentiation are quite complex. Details are provided in Chapter 18.*

WHAT IS SKIN?

- Largest organ
  - Surface area: ~22 square feet
  - Weight: ~10 to 11 pounds
- Consists of:
  - Epidermis (epithelial layer)
  - Dermis (CT layer)
  - Subcutaneous (hypodermis)



Totals

Anterior and posterior head and neck, 9%

Anterior and posterior upper limbs, 18%

Anterior and posterior trunk, 36%

Anterior and posterior lower limbs, 36%

100%

FIGURE 5-5 Lines of Cleavage of the Skin.
Lines of cleavage follow lines of tension in the skin. They reflect the orientation of collagen fiber bundles in the dermis.

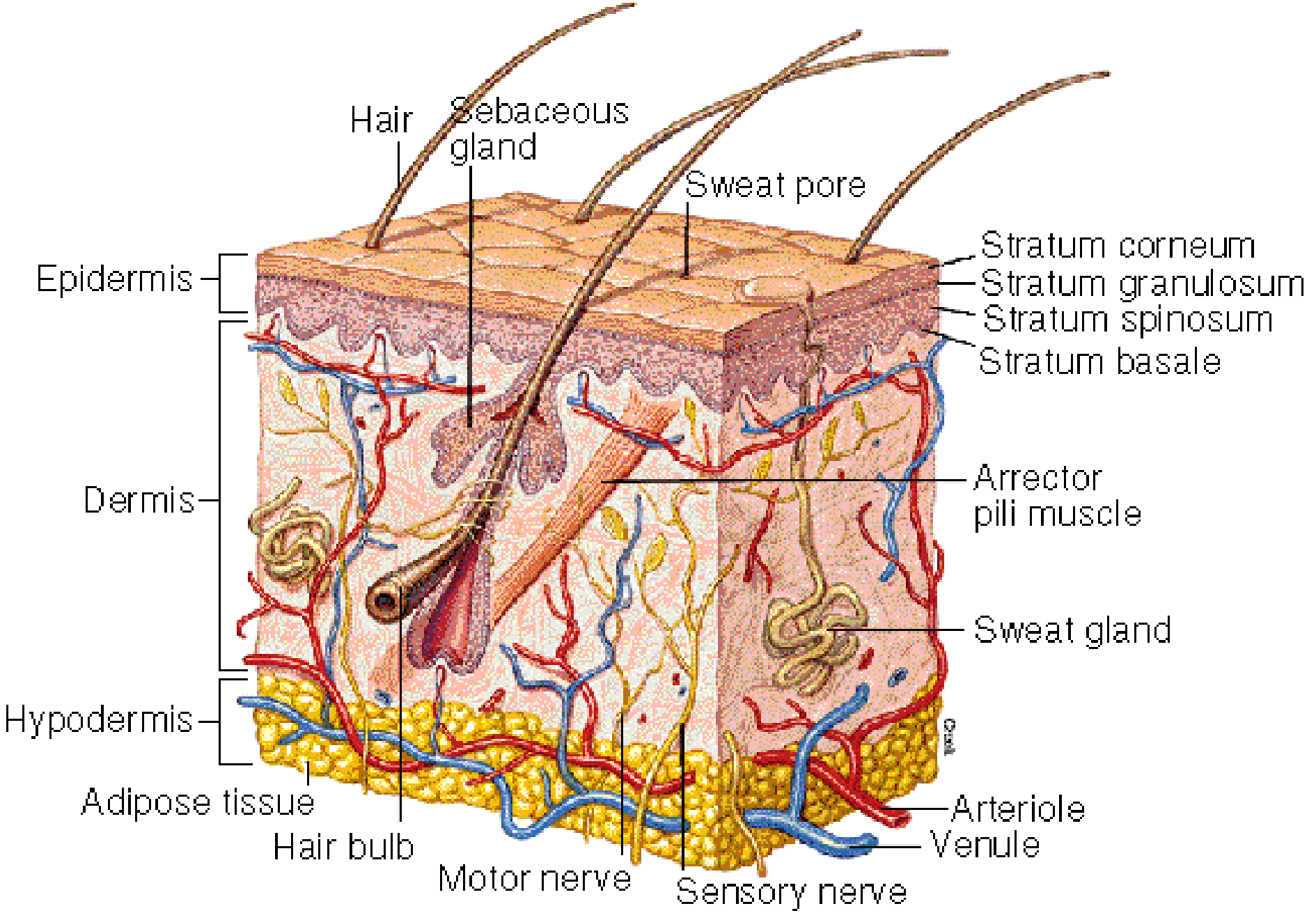
SKIN STRUCTURES

- The skin has two principal parts:
  - (1) the outer portion is called the **epidermis** and is composed of epithelial tissue;
  - (2) the inner portion is called the **dermis** and is composed of connective tissue.

SKIN STRUCTURES

- Subcutaeous layer
  - Beneath the dermis is the *subcutaneous layer* (also called the *superficial fascia* or **hypodermis***),* which is **not** considered part of the skin.
  - The subcutaneous layer consists of loose connective tissues (adipose and areolar tissues); it binds the skin loosely to the underlying tissues and organs.

A Diagram of the Skin. Figure 1.20



SKIN
SENSORY FUNCTIONS

- **(1) Sensation -**Receptors in the skin monitor 3 basic types of cutaneous sensations : **tactile**, **thermal**, and **pain**.
  - **Touch and Pressure Receptors:**
  - *Hair Root Plexuses*: dendrites arranged in a network around hair follicles; receptors that detect movement when hairs are disturbed.

SKIN
SENSORY FUNCTIONS

- *Corpuscles of Touch* (Meissner's corpuscles): encapsulated nerve endings; receptors that respond to low frequency vibrations, as well as to pressure and touch stimuli.
- *Tactile Discs* (Merkel's discs / Type I Cutaneous Mechanoreceptors) : expanded nerve endings (flattened dendrites); receptors for discriminative touch.

SKIN
SENSORY FUNCTIONS

- *Type II Cutaneous Mechanoreceptors* (end organs of Ruffini): expanded nerve endings embedded in the dermis; receptors that detect heavy and continuous touch.
- *Lamellated Corpuscles* (Pacinian corpuscles) : oval structures composed of a connective tissue capsule, layered like an onion, that enclose a dendrite; receptors that respond to pressure and high frequency vibrations.

SKIN
SENSORY FUNCTIONS

- *Free Nerve Endings* Free nerve endings are the receptors for both tickle and itch sensations.

- **Thermal Receptors** *(Thermoreceptors) Free Nerve Endings*
  - The sense receptors for cold and warm are called thermoreceptors. They are free (naked) nerve endings.

SKIN
SENSORY FUNCTIONS

- **Pain Receptors** *(Nociceptors) Free Nerve Endings*
  - The sense receptors for pain are called nociceptors. They are free (naked) nerve endings located between cells of the epidermis. Nociceptors respond to all types of high intensity stimuli and stimuli that cause tissue damage.

SKIN
OTHER FUNCTIONS

- **(2) Protection**
  - The skin protects underlying tissues from physical abrasion, bacterial invasion, dehydration, and ultraviolet radiation.

- **(3) Immunity**
  - Langerhans cells of the epidermis phagocytize antigens (foreign molecules).

SKIN
OTHER FUNCTIONS

- **(4) Excretion**
  - A small amount of salts and and several organic compounds are removed from the body in sweat.

SKIN
OTHER FUNCTIONS

- **(5) Blood Reservoir**
  - Extensive networks of blood vessels in the dermis carry 8 to 10 % of the total blood flow in a resting adult.
  - During vigorous exercise skin blood vessels constrict, shunting blood to skeletal muscles.

SKIN
OTHER FUNCTIONS

- **(6) Vitamin D Synthesis**
  - When ultraviolet light strikes the skin it converts a provitamin into vitamin D_3
  - Vitamin D_3 is carried by the blood to the liver and kidneys where enzymes modify it, forming calcitriol (active form of vitamin D).

SKIN
OTHER FUNCTIONS

- **(7) Body Temperature Regulation**
  - When vigorous exercise or high environmental temperatures causes the body temperature to rise, the evaporation of sweat helps cool the body. In response to low environmental temperatures, blood vessels in the dermis constrict; as a result of the reduced flow of blood to the skin, the body loses less heat by radiation.

EPIDERMIS

- Keratinocytes
- Melanocytes
- Langerhans cell
- Merkel cell & Merkel’s tactile disc

EPIDERMIS (outer, thinner portion)

- **Cell Types**:
  - *(1) Keratinocytes: produce* **keratin** (waterproof the skin).
  - *(2) Melanocytes: produce* **melanin** (absorb UV light).

EPIDERMIS

- **Cell Types***:*
  - *(3) Langerhans cells: involved* in the immune response; phagocytize antigens (foreign molecules).
  - *(4) Merkel's discs (*Tactile Discs *): sensory* receptors for touch.

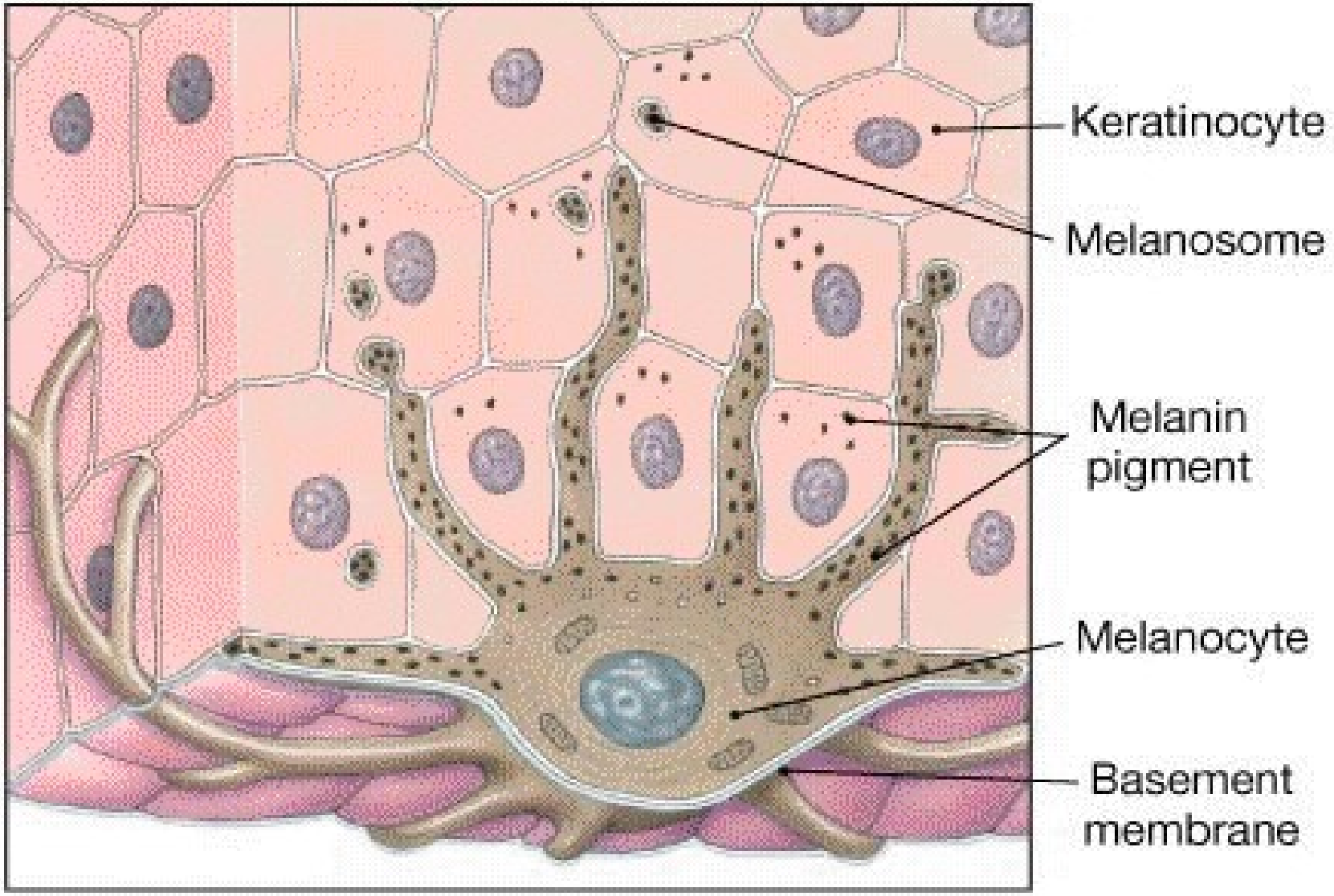


FIGURE 5-4 Melanocytes. **(a)** The location and orientation of melanocytes in the stratum germinativum of a black person.

What Produces Skin Color?

- Melanin - brown
- Carotene - yellow-orange
- Blood (hemoglobin) - red

Stratified Squamous Epithelium

- *Stratified Squamous Epithelium* consists of several layers of cells in which the top layer of cells is flat and the deeper layers of cells vary in shape from cuboidal to columnar.
  - The basal cells replicate by mitosis and ultimately work their way to the surface.

Stratified Squamous Epithelium

- In *keratinized stratified squamous epithelium*, a tough layer of keratin (a protein resistant to friction and repels bacteria) is deposited in the surface cells.
- *Nonkeratinized stratified squamous epithelium* does not contain keratin and remains moist.

EPIDERMAL LAYERS

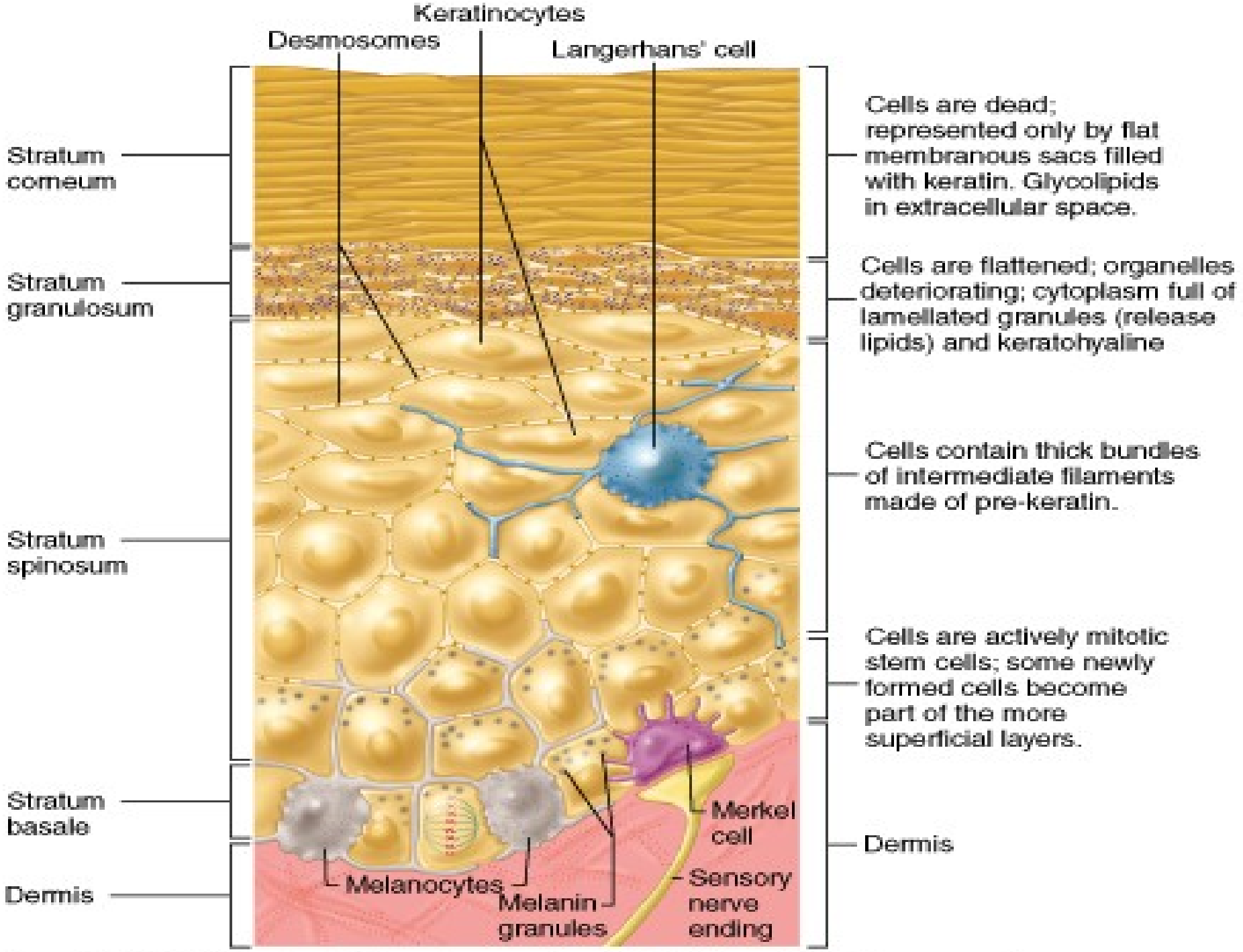
- Stratum basale (germinativum)
- Stratum spinosum
- Stratum granulosum
- Stratum lucidum
- Stratum corneum

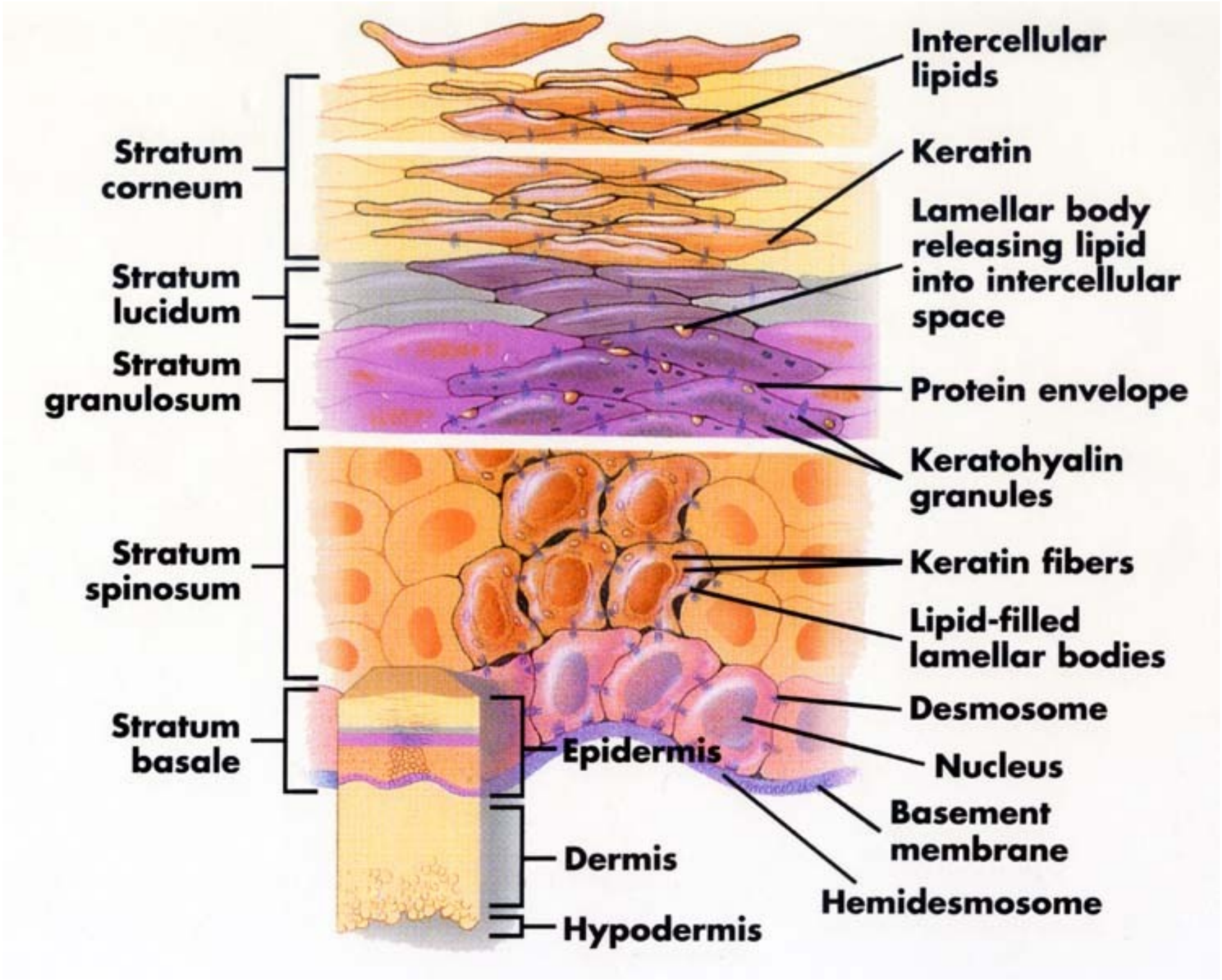
EPIDERMIS

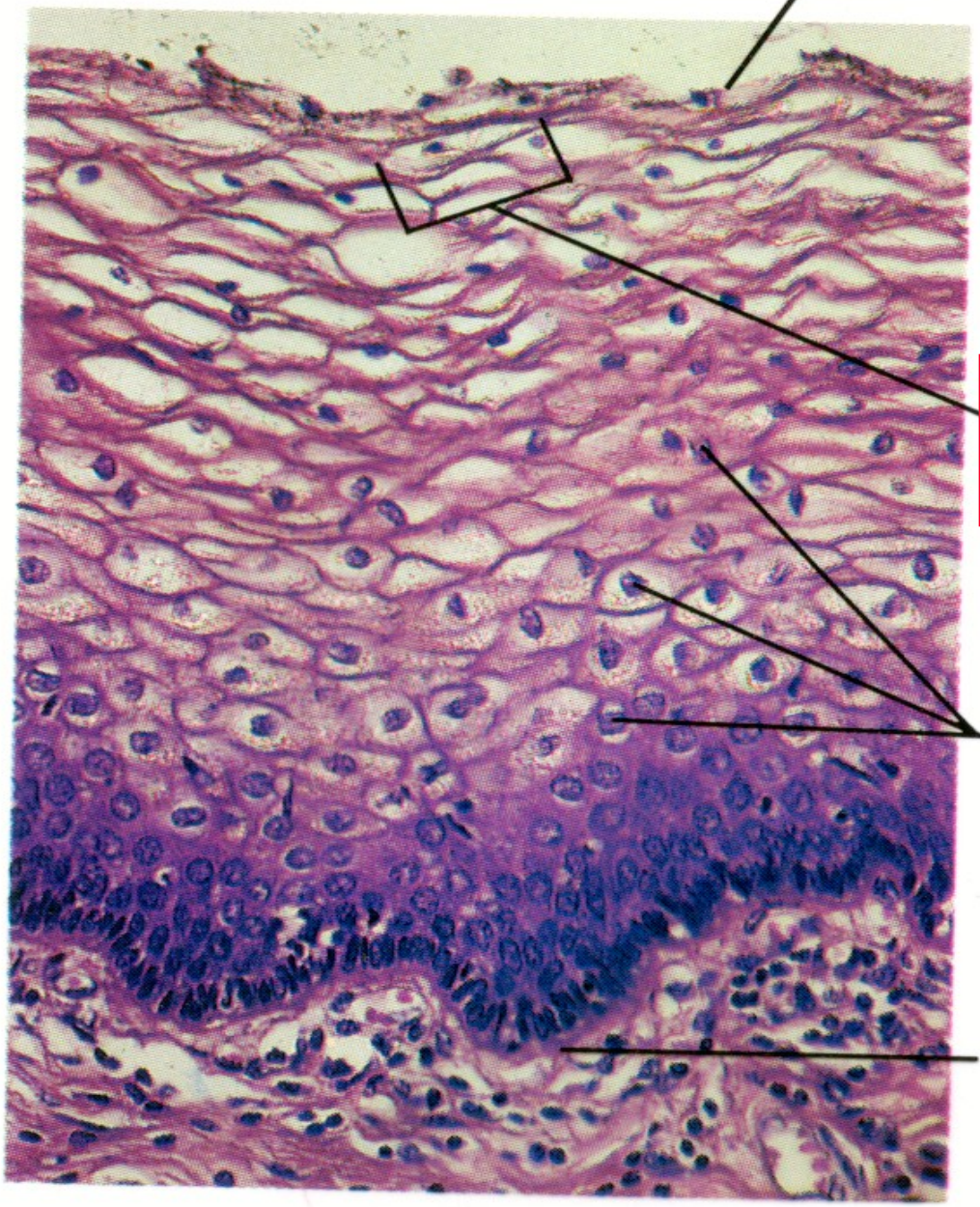
- **Layers** (arranged from superficial to deep)
  - *(1) Stratum Corneum:* flat, dead cells completely filled with keratin.
  - *(2) Stratum Lucidum:* clear, flat, dead cells; present in thick skin of palms and soles.
  - *(3) Stratum Granulosum: flattened* cells; produce the precursor of keratin.

EPIDERMIS

- **Layers** (arranged from superficial to deep)
  - *(4) Stratum Spinosum: polyhedral* cells; keratinocytes take in melanin by phagocytosis.
  - *(5) Stratum Basale: single* layer of cuboidal to columnar cells; stem cells produce keratinocytes.


Keratinocytes
Desmosomes
Langerhans' cell
Stratum corneum
Stratum granulosum
Stratum spinosum
Stratum basale
Dermis
Cells are dead; represented only by flat membranous sacs filled with keratin. Glycolipids in extracellular space.
Cells are flattened; organelles deteriorating; cytoplasm full of lamellated granules (release lipids) and keratohyaline
Cells contain thick bundles of intermediate filaments made of pre-keratin.
Cells are actively mitotic stem cells; some newly formed cells become part of the more superficial layers.
Dermis
Merkel cell
Melanocytes
Melanin granules
Sensory nerve ending


Intercellular lipids
Keratin
Lamellar body releasing lipid into intercellular space
Protein envelope
Keratohyalin granules
Keratin fibers
Lipid-filled lamellar bodies
Desmosome
Nucleus
Basement membrane
Hemidesmosome
Stratum corneum
Stratum lucidum
Stratum granulosum
Stratum spinosum
Stratum basale
Epidermis
Dermis
Hypodermis


Free surface
Moist stratified squamous epithelial cell
Nuclei
Basement membrane

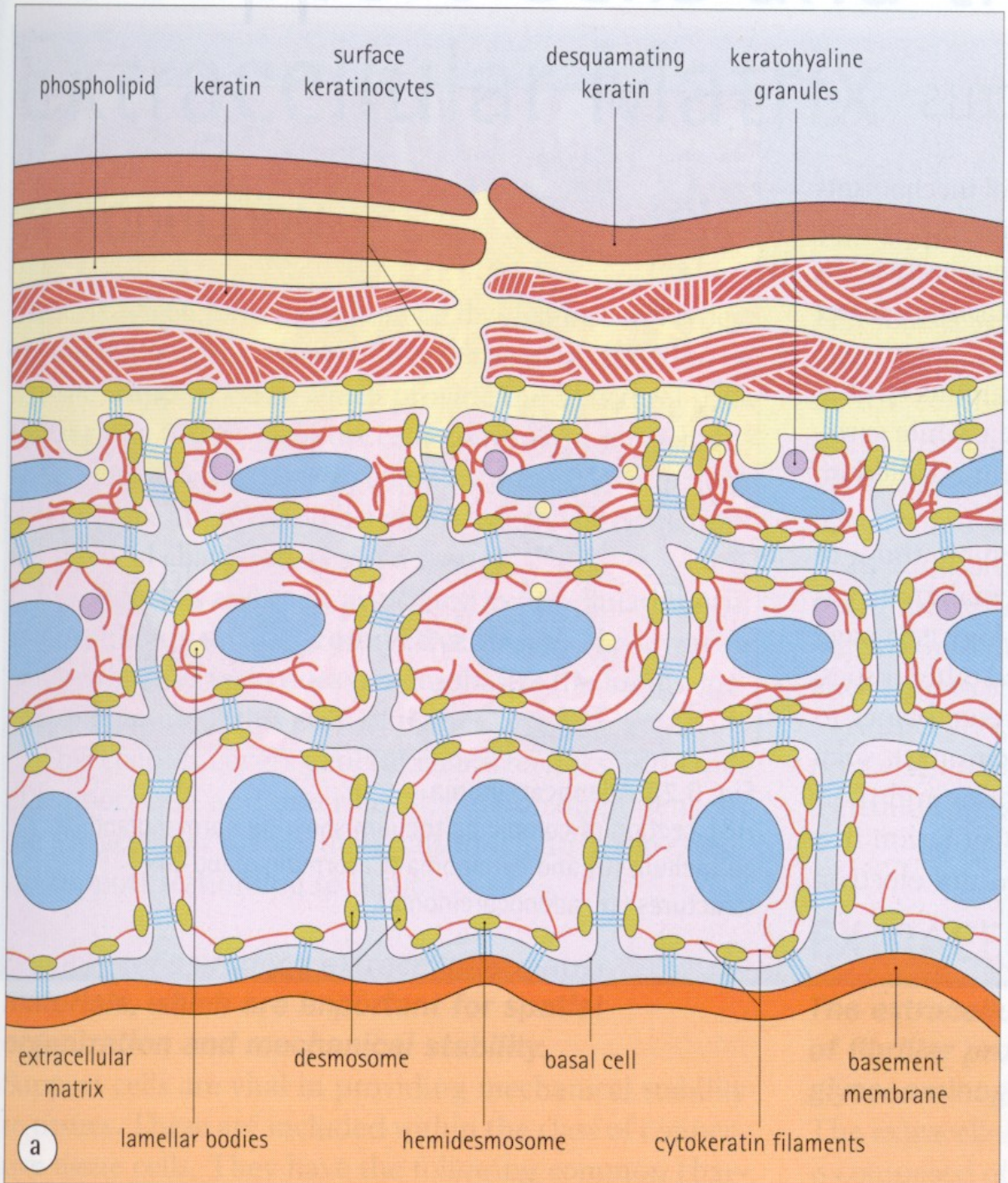
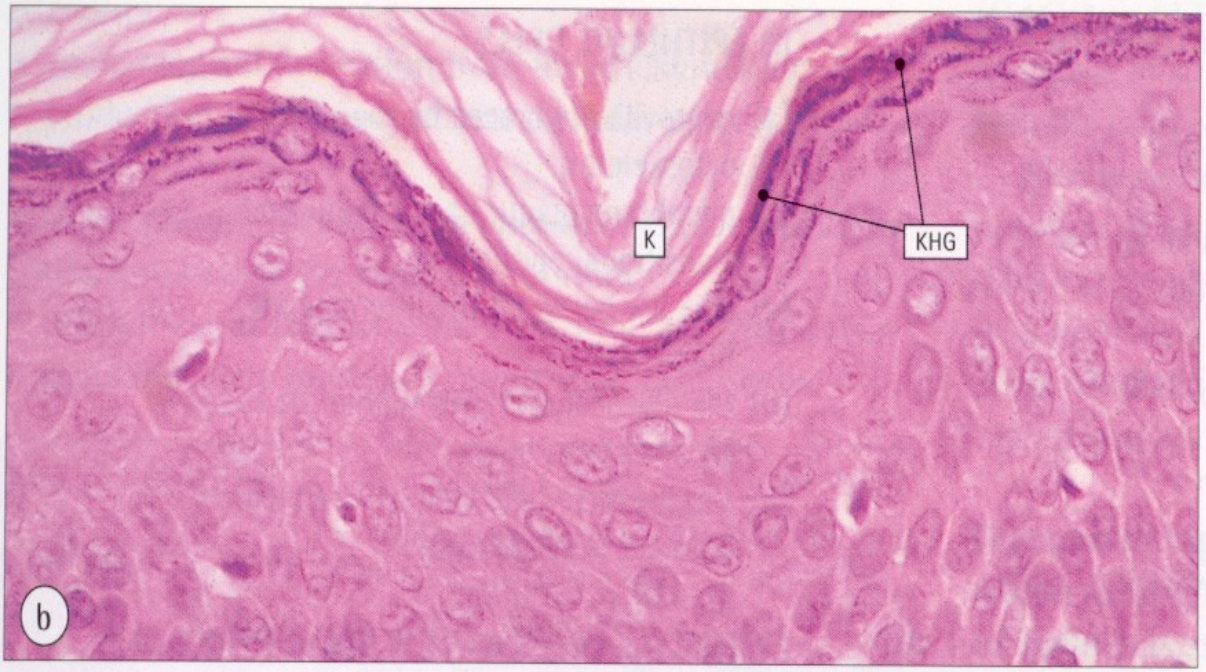
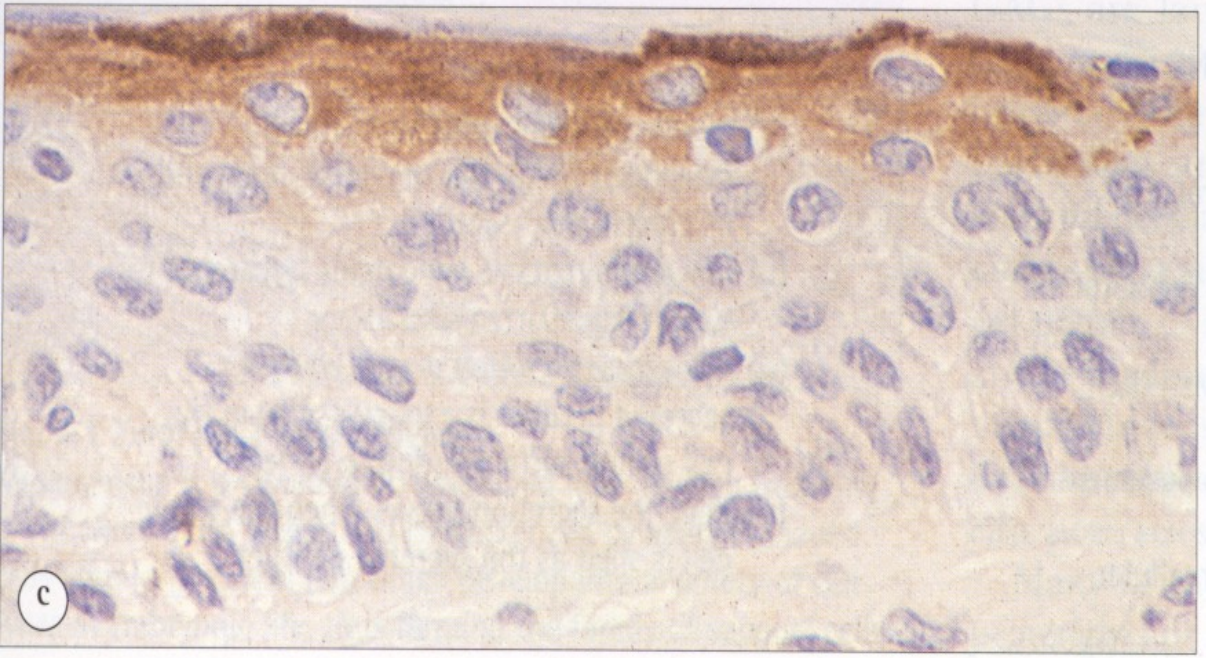


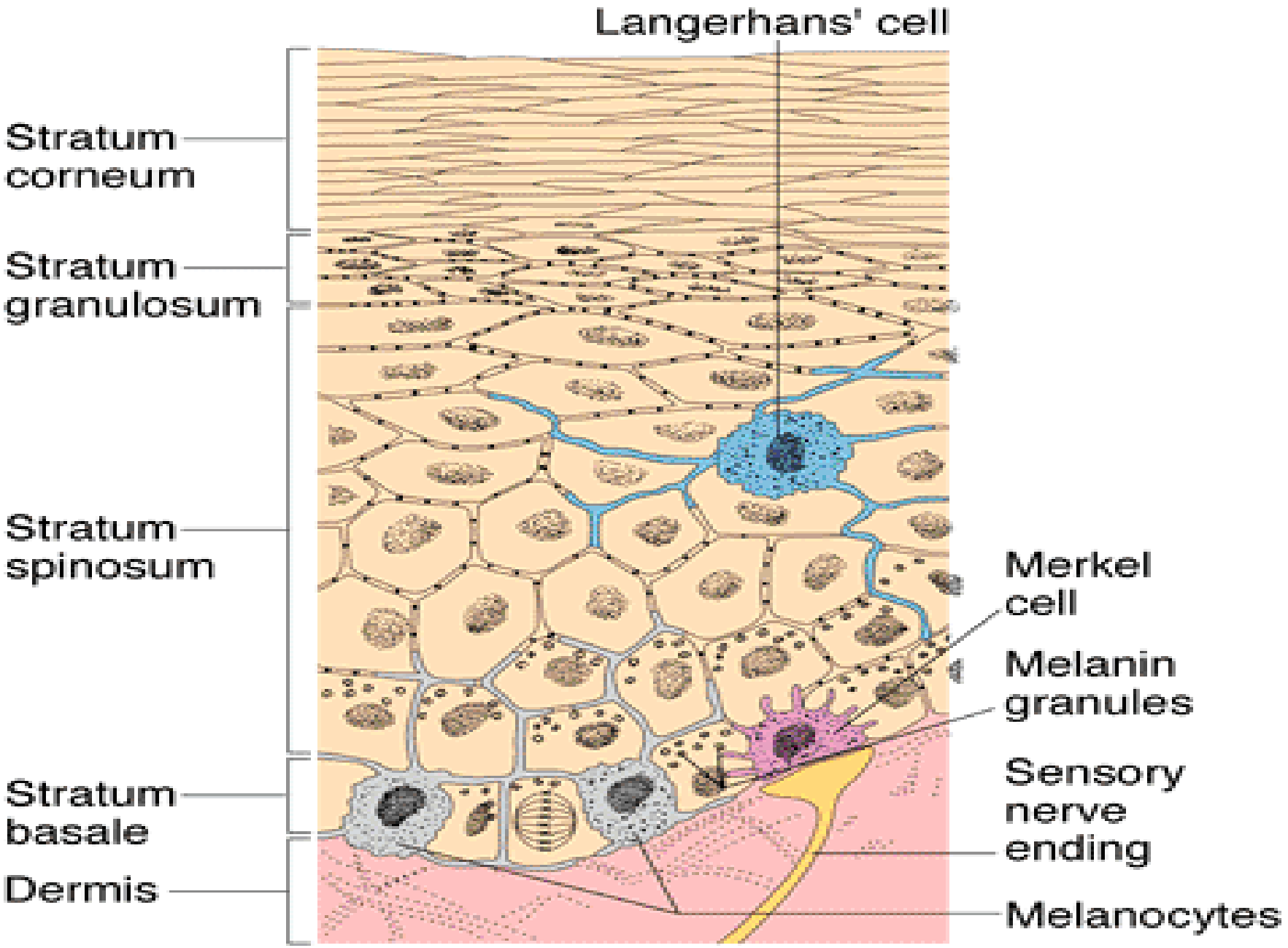
Fig. 3.27 Keratinization.
(a) Basal cells of keratinizing squamous epithelium are anchored by hemidesmosomes and desmosomes to basement membrane and adjacent cells, and contain abundant cytokeratin intermediate filaments (tonofibrils). As the cells differentiate and move up the stratified epithelium they remain tightly bound by desmosomal junctions, but the cytokeratin proteins change to higher molecular weight forms and the cells develop lamellar bodies. Lamellar bodies are membrane-bound granules containing phospholipids which are secreted by exocytosis into the extracellular space and form a lamellar sheet between cells in the upper epithelium. Cells in the upper part of the epithelium express genes coding for a variety of specialized proteins which interact with the cytokeratin filaments and the cell membrane to produce a resilient and mechanically robust compact mass (**keratin**). Small granules (**keratohyaline granules**) contain some of these specialized proteins. A prominent protein (**involucrin**) associates with and thickens the cell membrane.

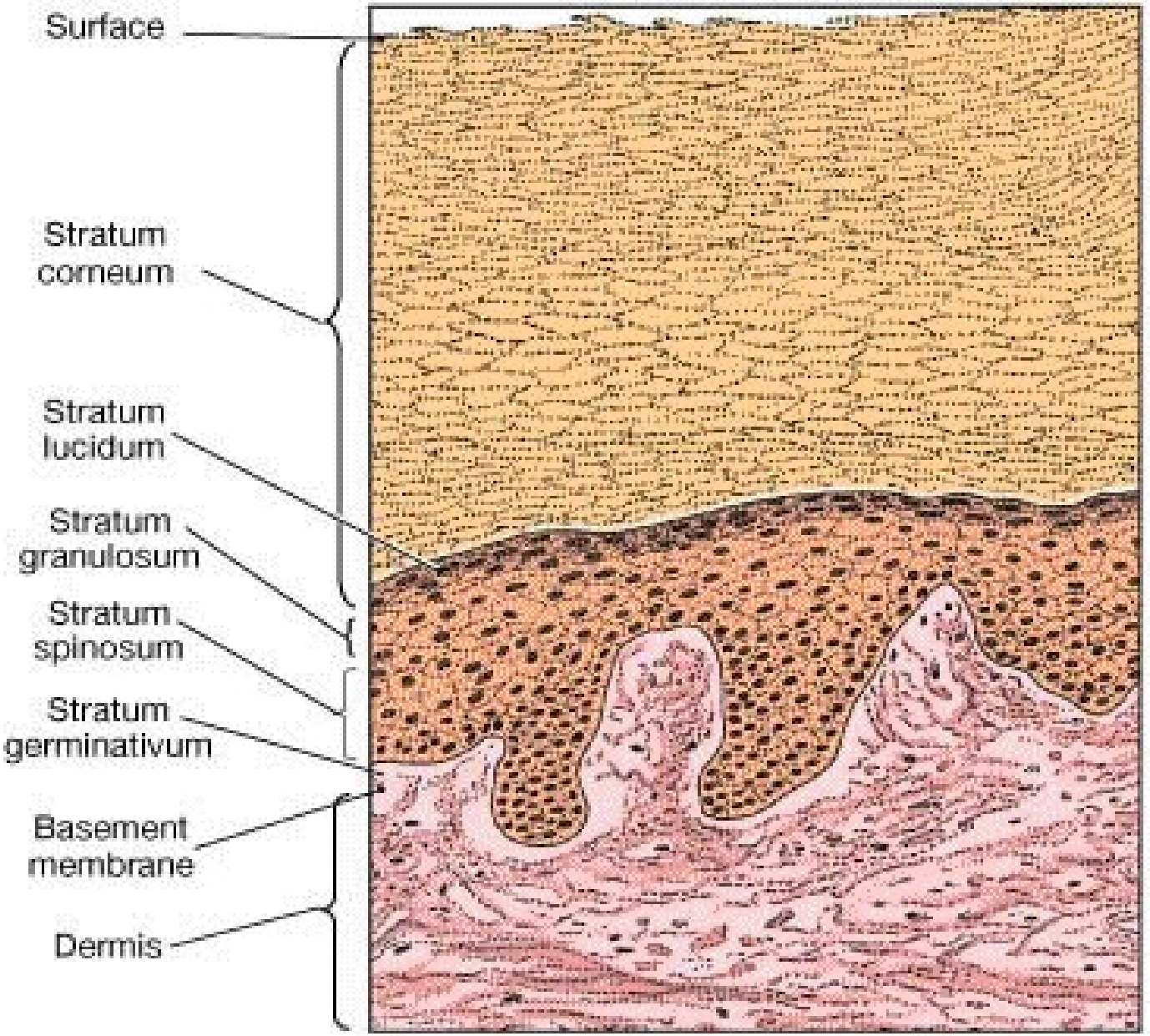


(b) H&E section of keratinized squamous epithelium. Note the purplish keratohyaline granules (KHG) and the absence of nuclei in the surface keratin layer (K).



(c) Keratinizing squamous epithelium stained to show involucrin (brown), which is only present in the upper keratinizing part of the epithelium.





● ***FIGURE 5-3*** **The Structure of the Epidermis.** A portion of the epidermis in thick skin, showing the major stratified layers of epidermal cells. (LM × 210)

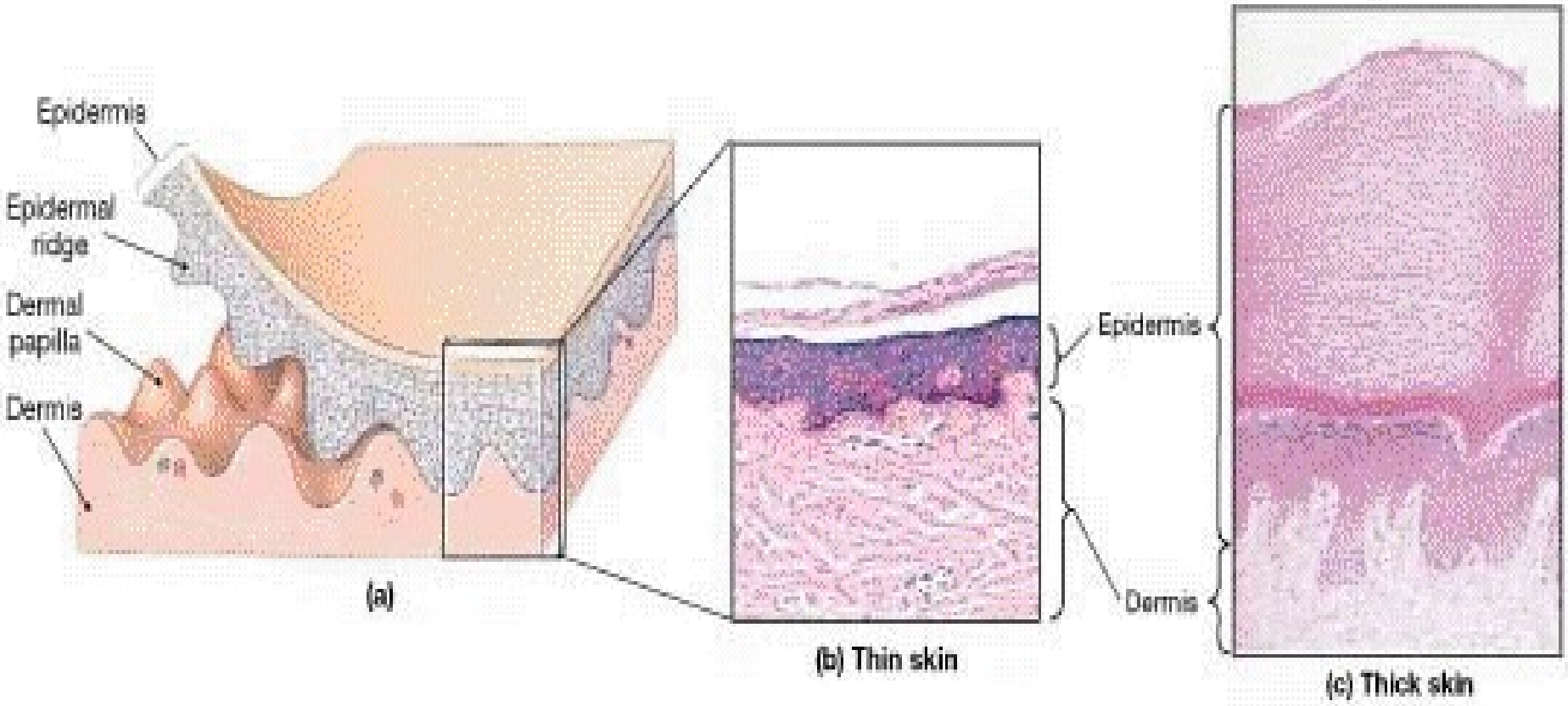
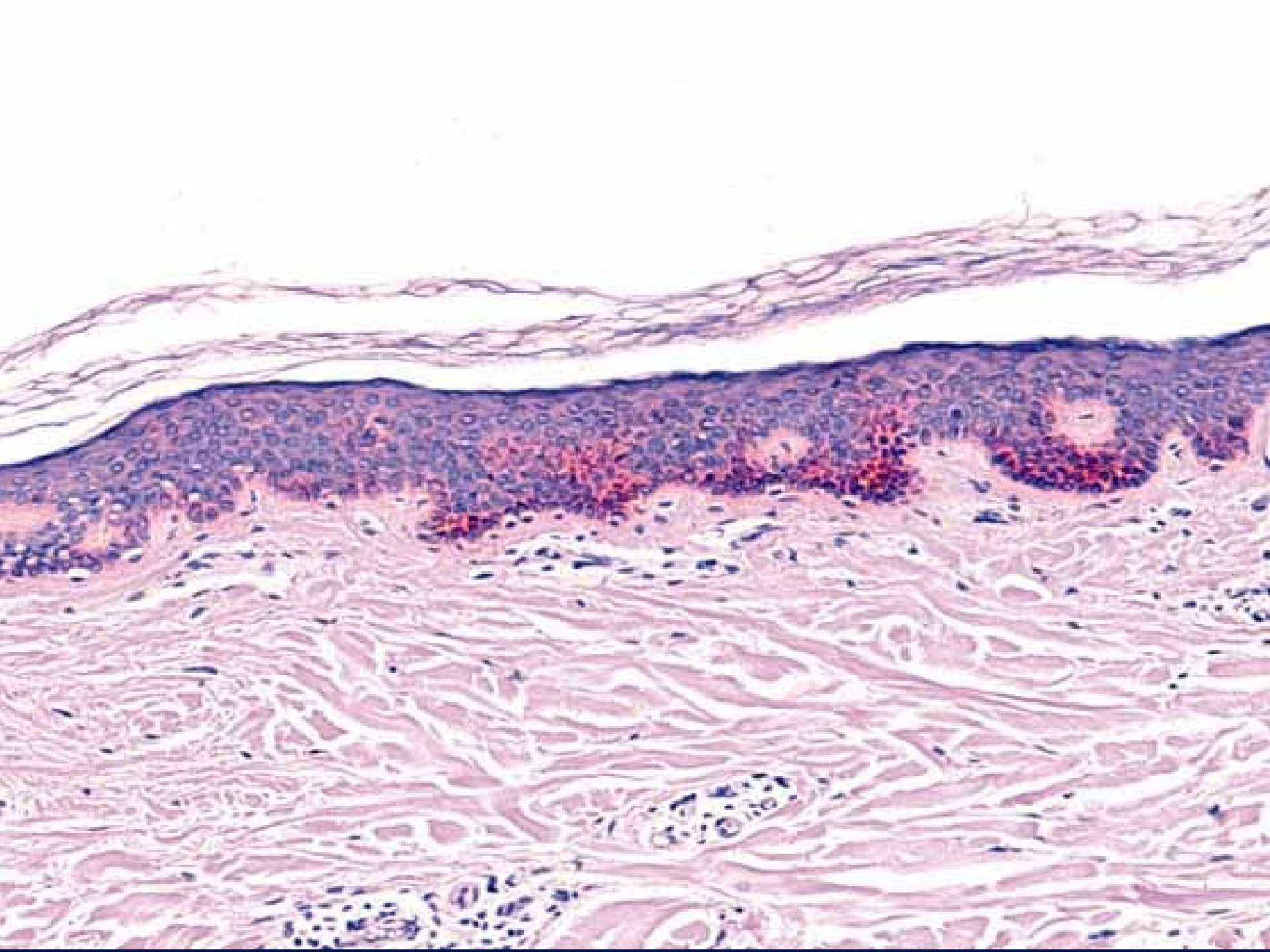
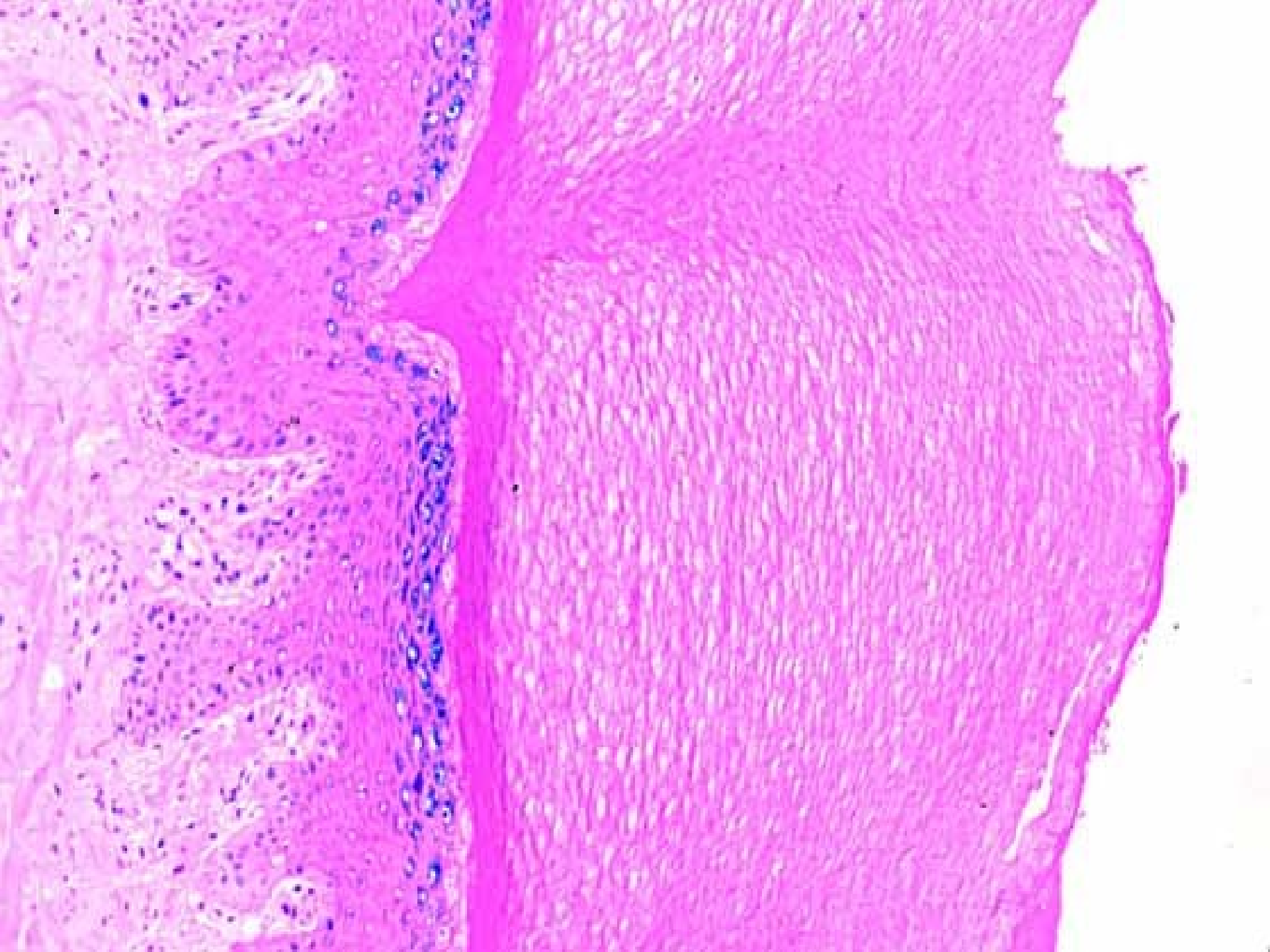


FIGURE 5-2 Thin and Thick Skin. **(a)** The basic organization of the epidermis. The proportions of the various layers change depending on the location sampled. **(b)** Thin skin covers most of the exposed body surface. (LM × 144) **(c)** Thick skin covers the surfaces of the palms and soles. (LM × 135)





DERMIS

- Dermal papillae - increase surface area
- Merkel’s tactile disc - senory neuron
- Meissner’s corpuscle - touch
- Pacinian corpuscle - pressure
- Free nerve endings - for pain, temperature, tickling, & itching

DERMIS (inner, thicker portion)

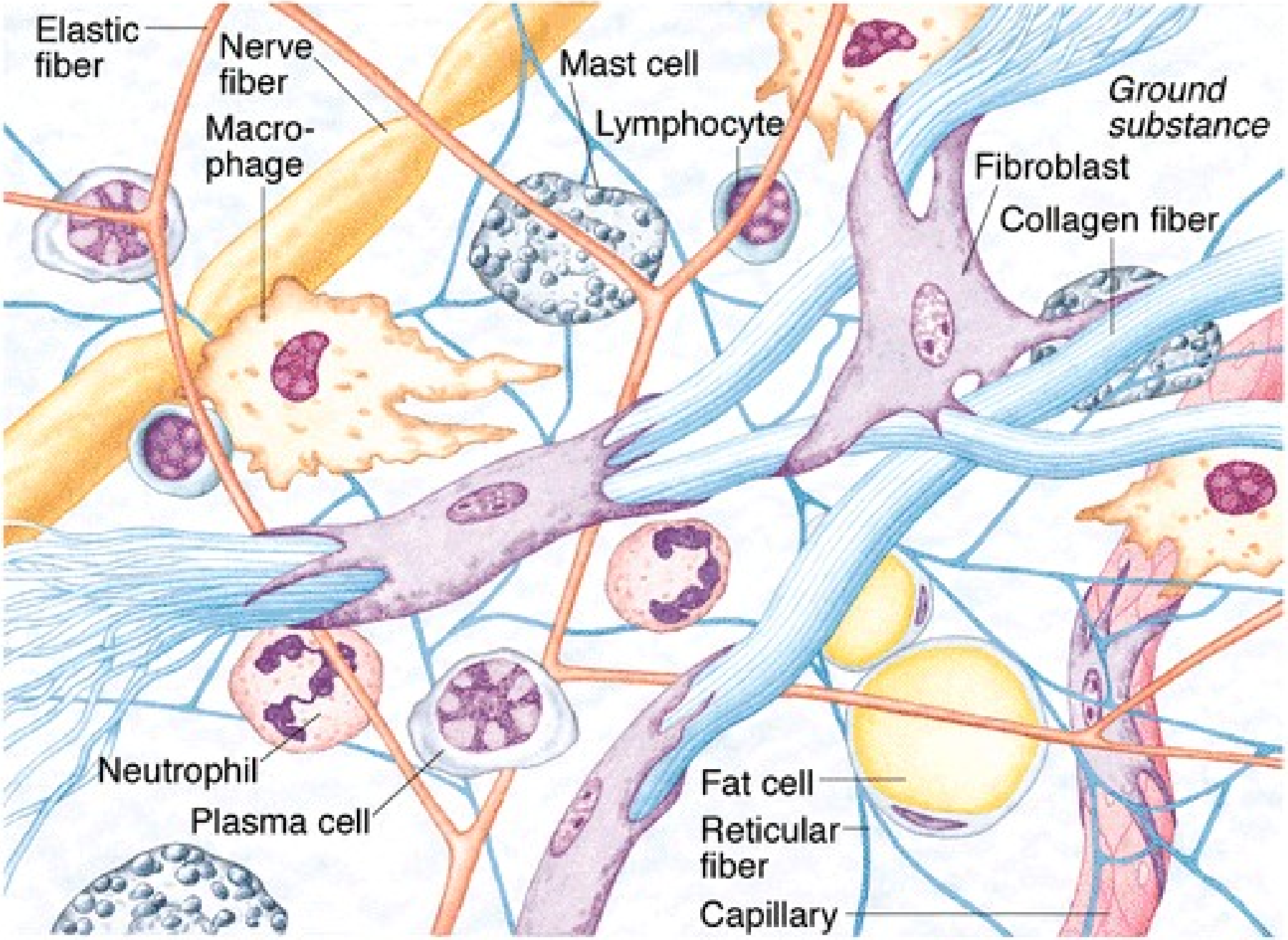
- **Cell Types:**
  - *(1) Fibroblasts: produce* fibers (collagen, reticular, and elastic) and ground substance.
  - *(2) Macrophages: phagocytize* bacteria and foreign substances.

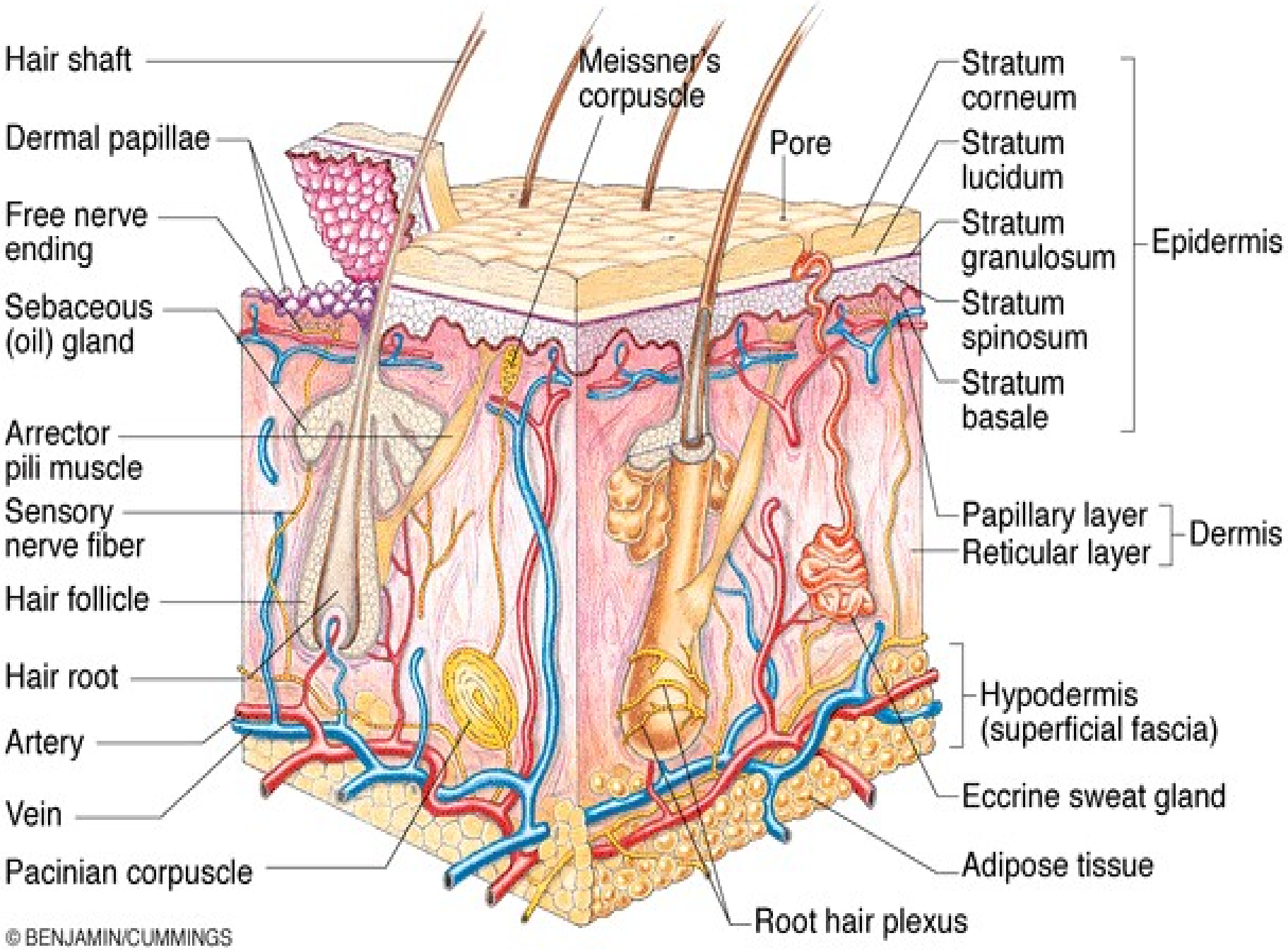
DERMIS (inner, thicker portion)

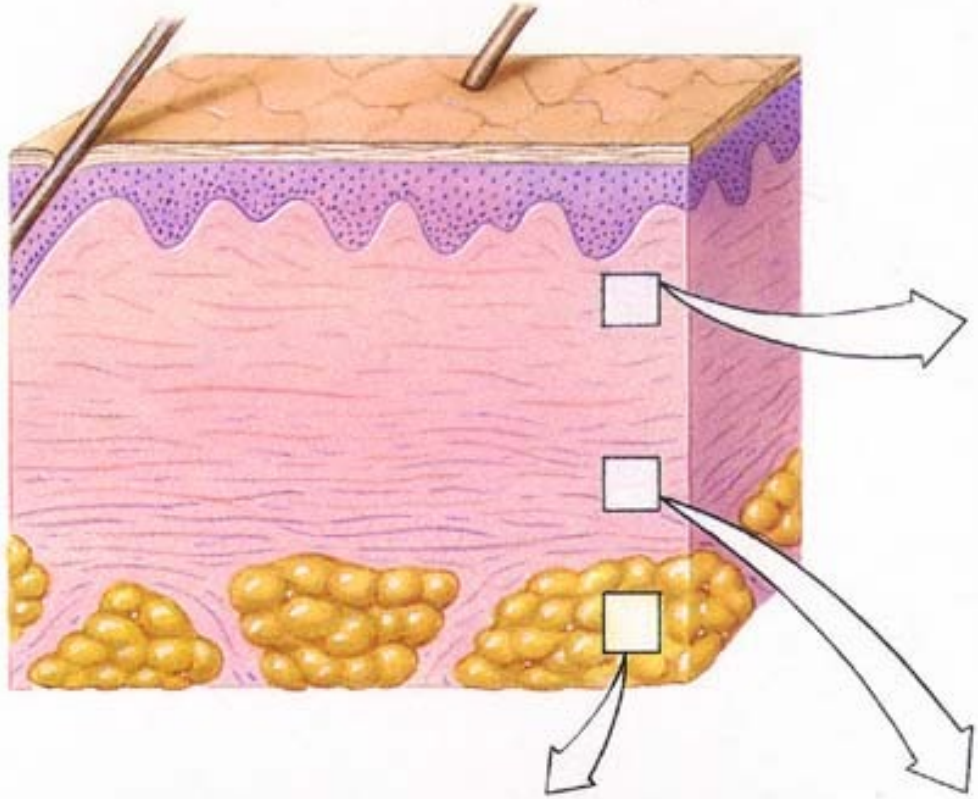
- **Cell Types:**
  - *(3) Adipocytes (fat cells): store* triglycerides (energy reservoir); insulate; cushion.
  - *(4) Sensory Receptors: free* and encapsulated nerve endings sensitive to specific stimuli.

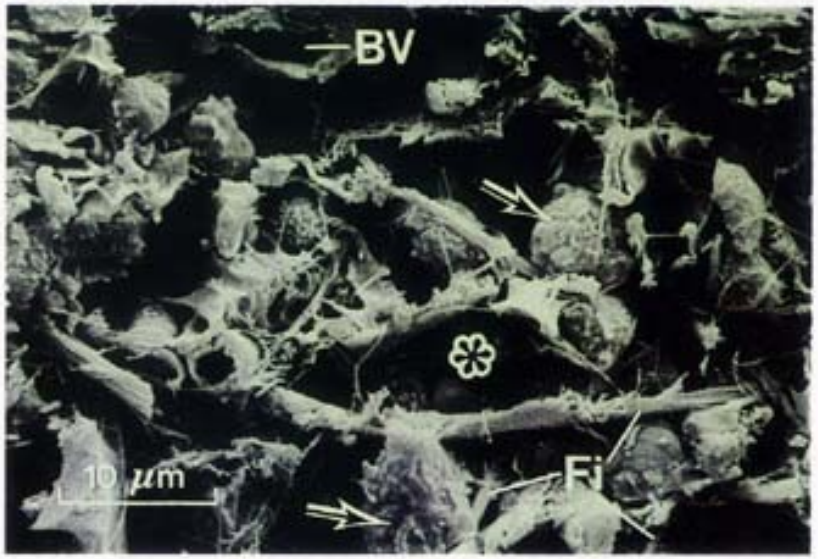
DERMIS (inner, thicker portion)

- **Regions**
  - *(1) Papillary Region: outer* 1/5 of the dermis; consists of areolar connective tissue.
  - *(2) Reticular Region: inner* 4/5 of the dermis; consists of dense, irregular connective tissue.
- *Dermal Papillae: projections* of dermis that extend into the epidermis to increase surface area.

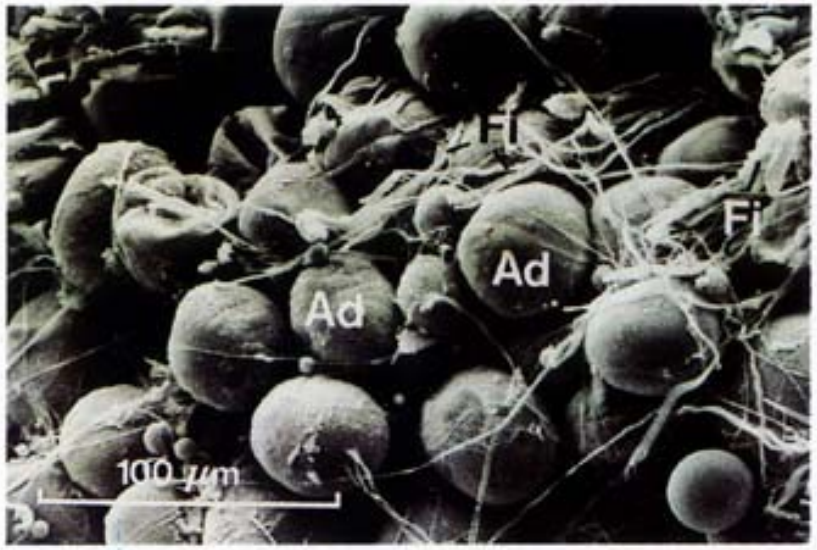



Hair shaft
Dermal papillae
Free nerve ending
Sebaceous (oil) gland
Arrector pili muscle
Sensory nerve fiber
Hair follicle
Hair root
Artery
Vein
Pacinian corpuscle
Meissner's corpuscle
Pore
Root hair plexus
Stratum corneum
Stratum lucidum
Stratum granulosum
Stratum spinosum
Stratum basale
Epidermis
Papillary layer
Reticular layer
Dermis
Hypodermis (superficial fascia)
Eccrine sweat gland
Adipose tissue
© BENJAMIN/CUMMINGS





(a) Papillary layer of dermis



(c) Subcutaneous layer

(b) Reticular layer of dermis

GLANDS

- Sebaceous
- Sweat (Sudoriferous)
- Ceruminous
- Mammary

EPIDERMAL DERIVATIVES

- **Glands** -Several kinds of glands are associated with the skin:
- ***Sebaceous*** *glands* - **Holocrine**
- ***Sweat (Sudoriferous)*** *glands* -**Merocrine**
  - **Eccrine** sweat glands
  - **Apocrine** sweat glands
    - **Ceruminous** (earwax) glands -*cerumen*
    - **Mammary** glands - *milk*

EPIDERMAL DERIVATIVES

- ***Sebaceous (Oil) glands*** which secrete **sebum** – a oily secretion which has a bactericidal action.
  - They function as **holocrine** glands.
  - They are found all over the body except on the palms and soles.
  - are usually associated with hair follicles;
  - **sebum** moistens hairs and waterproofs the skin.

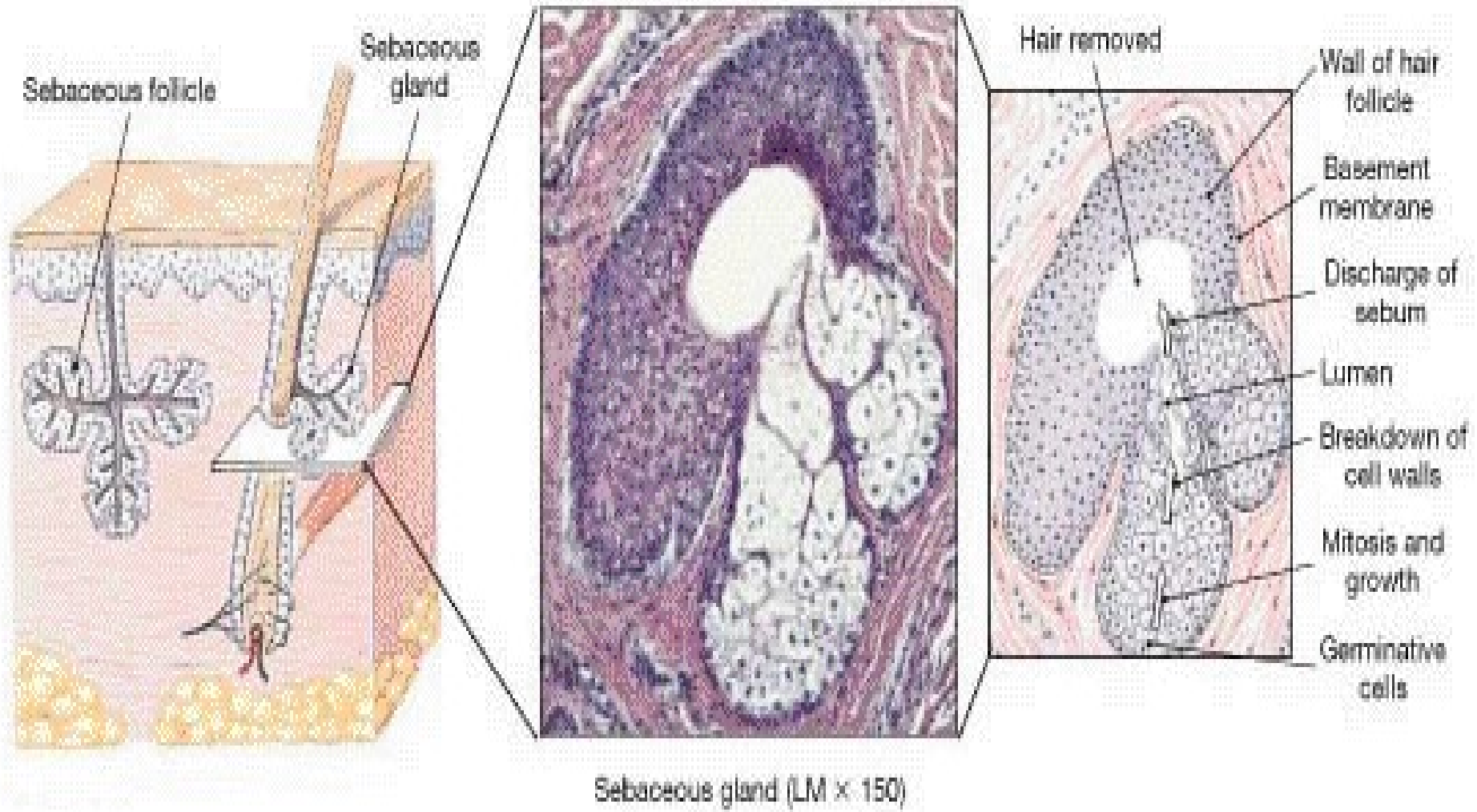


FIGURE 5-8 Sebaceous Glands and Follicles. The structure of sebaceous glands and sebaceous follicles in the skin.

EPIDERMAL DERIVATIVES

- **Glands** -There are two principal types:
- ***Sudoriferous*** *or* ***Merocrine (Sweat) glands****:*
  - (1) ***eccrine*** sweat glands are most numerous in the palms and the soles; and
  - (2) ***apocrine*** sweat glands are found mainly in the skin of the axilla (armpit), pubic region, and areolae (pigmented regions) of the breasts. Their secretions consist of sweat, plus fatty substances and proteins. These produce the bodies **odor** due to decomposition by bacteria on the skin.

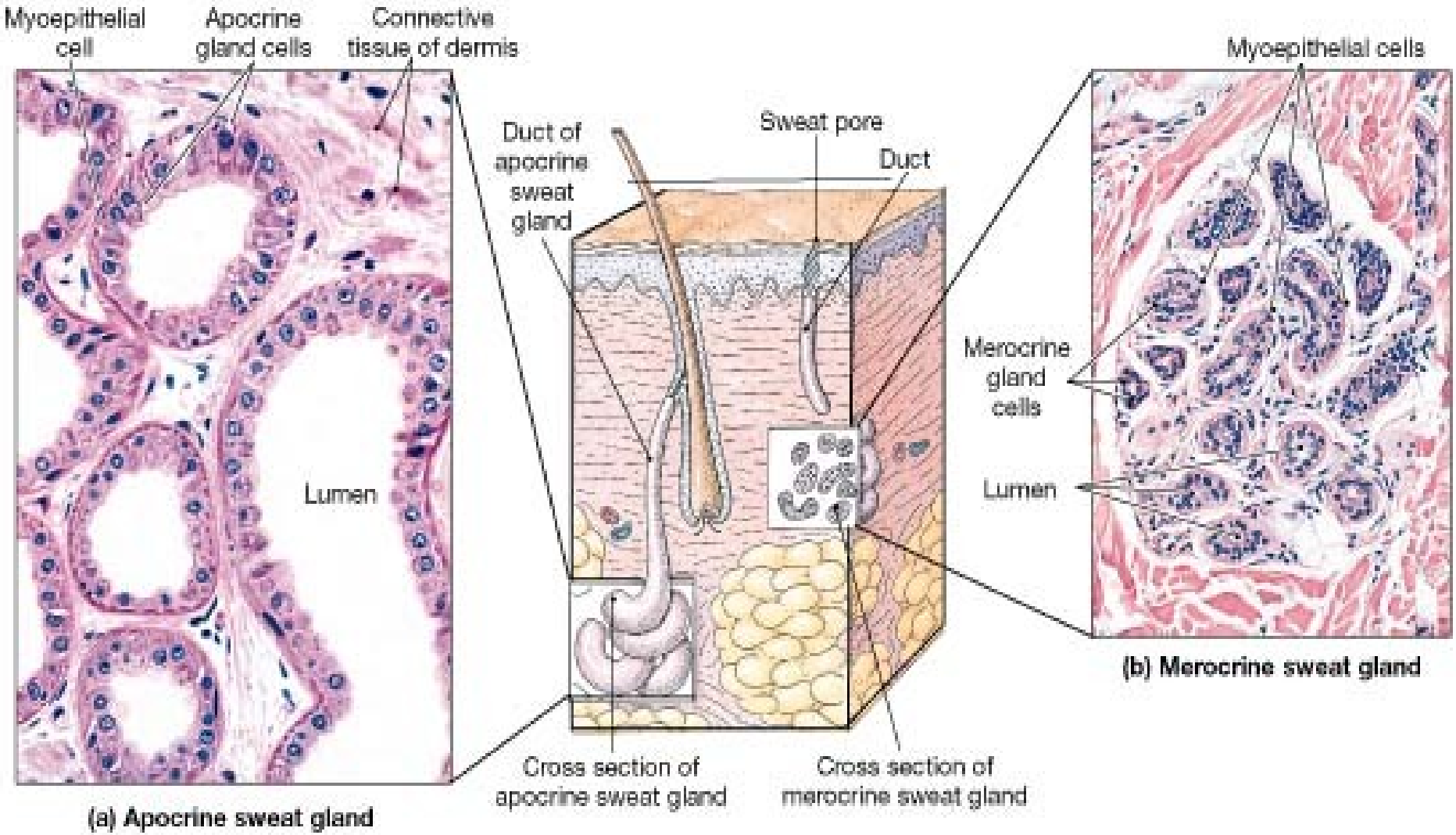
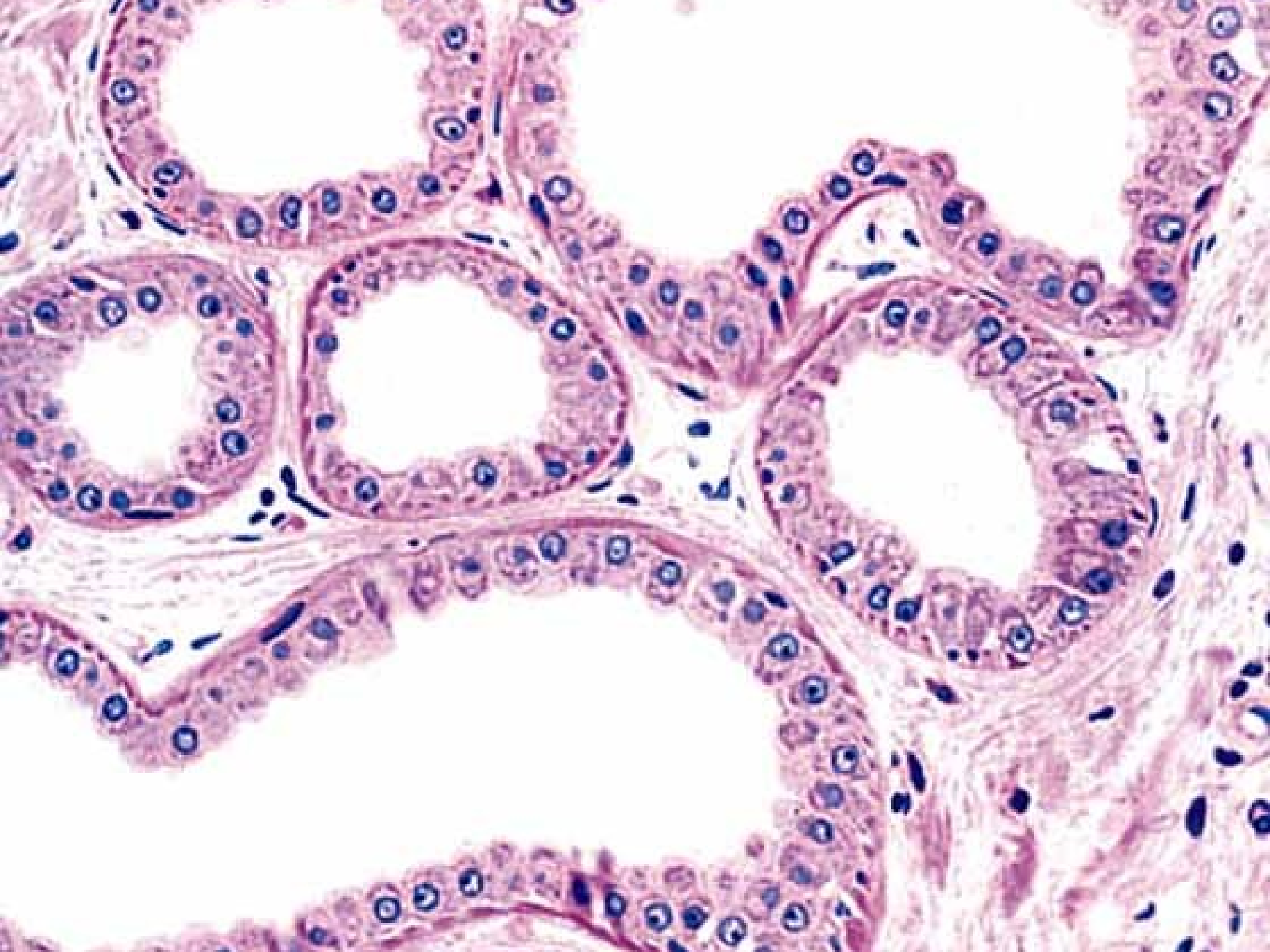
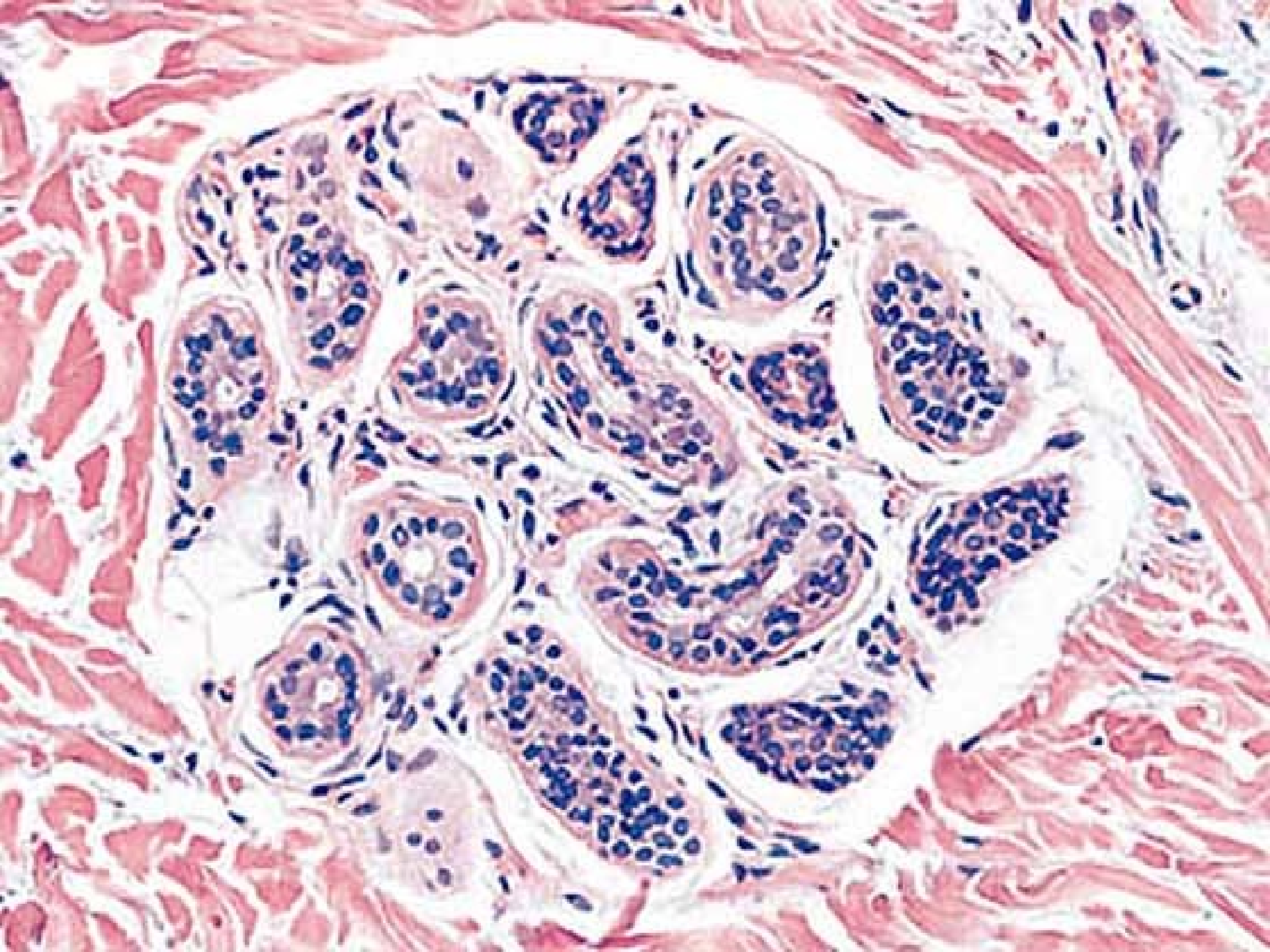
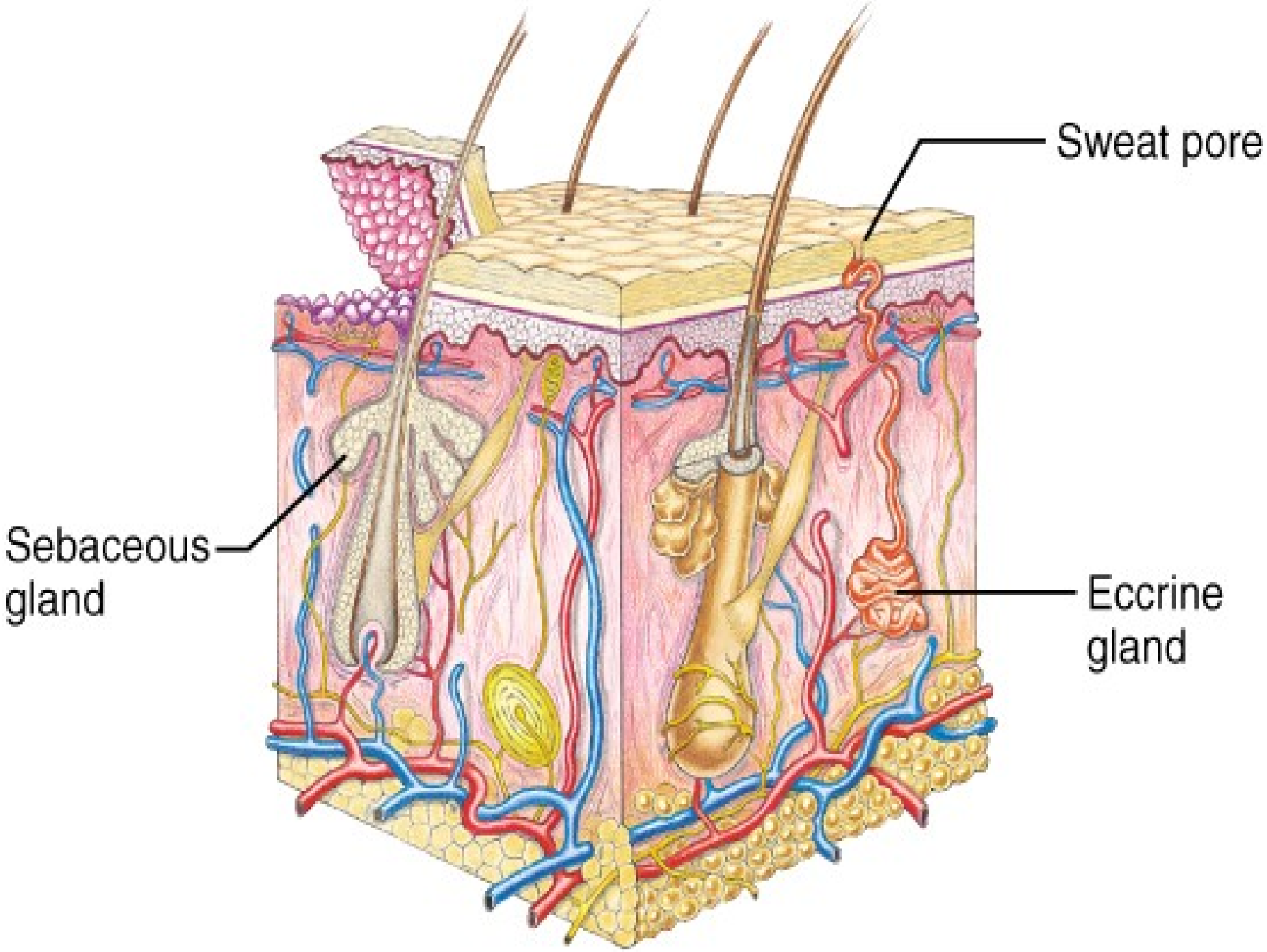


FIGURE 5-9 Sweat Glands. **(a)** Apocrine sweat glands are located in the axillae, groin, and nipples. These glands produce a thick, odorous fluid by ~~apocrine~~ secretion. (LM × 369) **(b)** Merocrine sweat glands produce a watery fluid by merocrine secretion. (LM × 194)






Sweat pore
Sebaceous gland
Eccrine gland

EPIDERMAL DERIVATIVES

- **Glands** -
  - ***Ceruminous glands*** secrete a waxy substance which combines with the secretions of sebaceous glands to produce *cerumen.*
  - Cerumen provides a sticky barrier that traps foreign particles in the ear canal.

HAIR FOLLICLE

- Bulb
  - Hair root
    - Medulla
    - Cortex
    - Cuticle of the hair
  - Hair follicle
    - Internal/external sheaths
- Shaft

HAIR STRUCTURE

- Arrector pili muscle
  - Under autonomic control
  - Straighten shaft
- Sebaceous (oil) gland
  - Secrete sebum
  - Prevents hair from drying out

EPIDERMAL DERIVATIVES

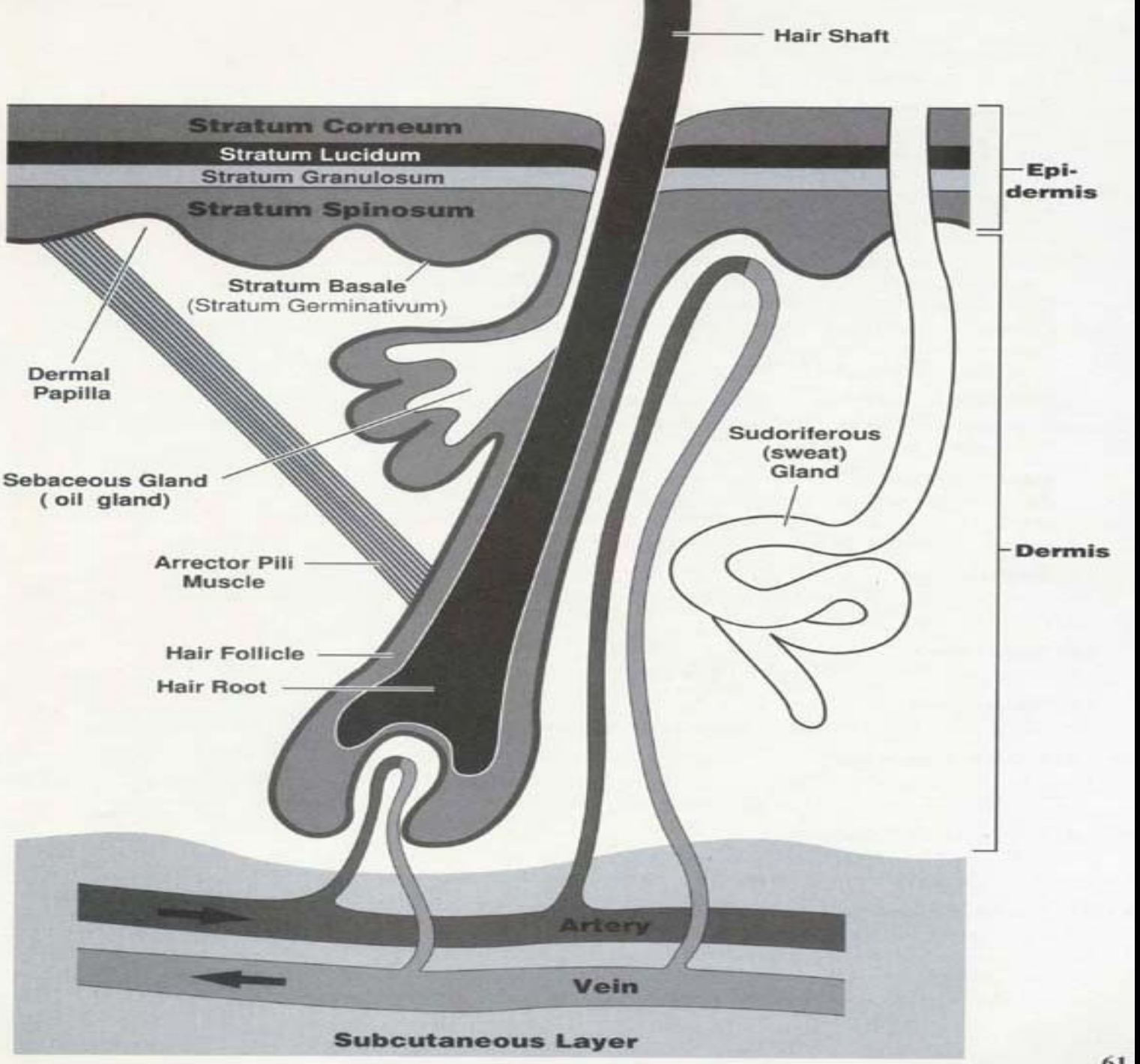
- Hair
  - Primary function: protection
- Glands
  - Cool; maintain skin & hair
- Nails (a characteristic of Primate)
  - Protect
  - Grasp, scratch, manipulate

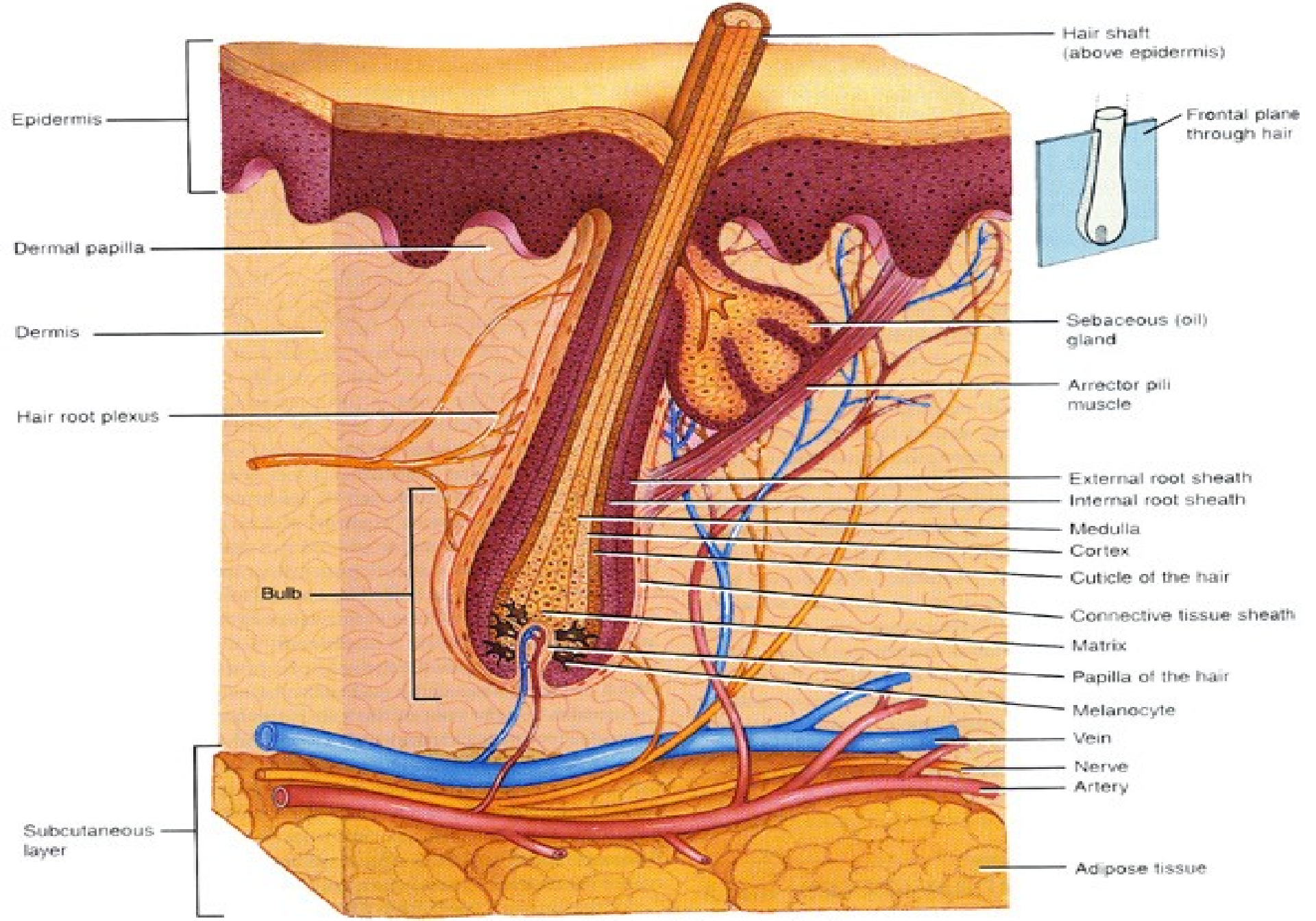
EPIDERMAL DERIVATIVES

- **Hairs (Pili)**
  - Hair is composed of dead, keratinized cells welded together.
  - A hair consists of a *shaft* above the surface, a *root* that penetrates the dermis and subcutaneous layer, and a *hairfollice* that surrounds the root.

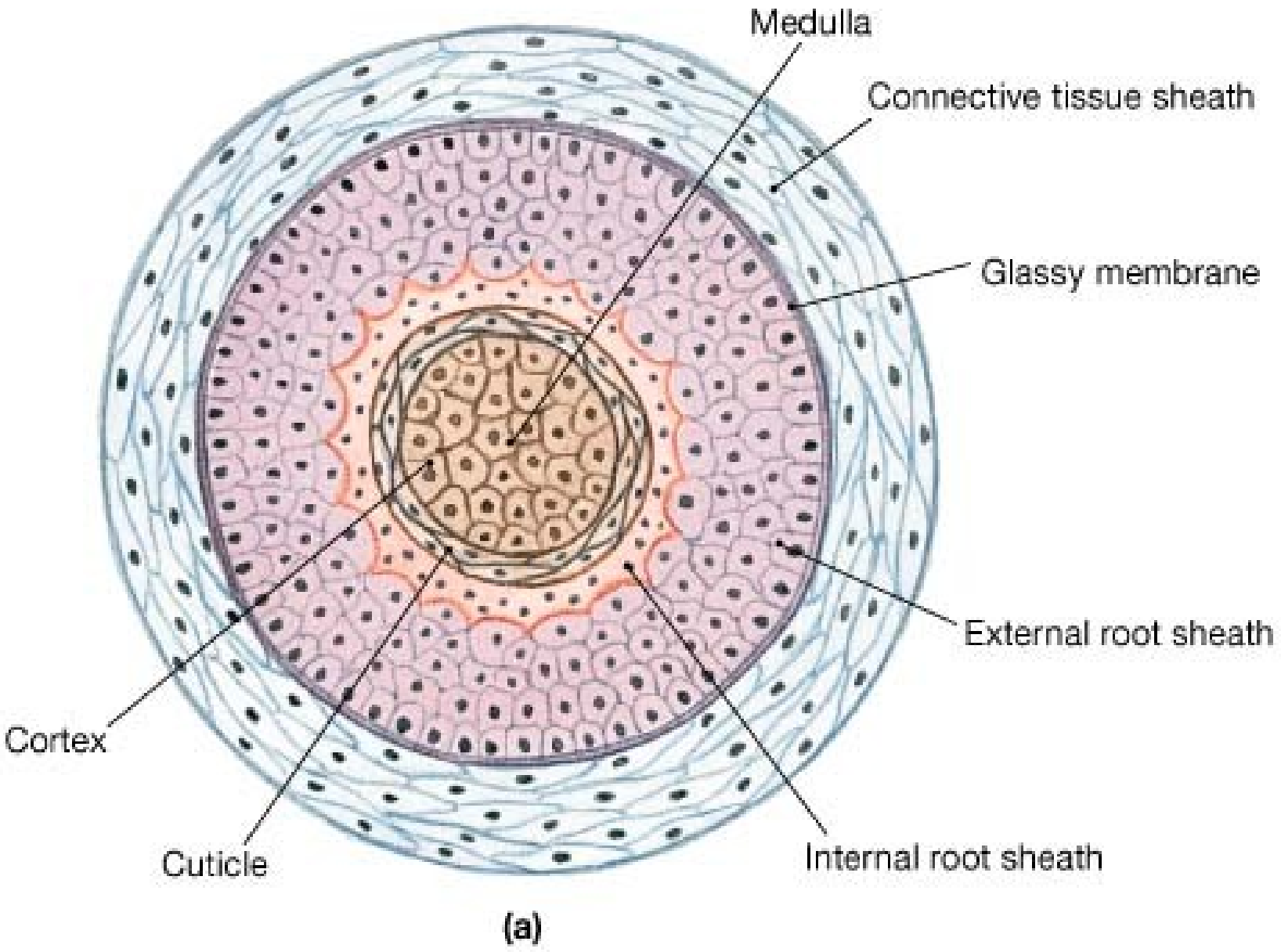
EPIDERMAL DERIVATIVES

- **Hairs (Pili)**
  - *Arrector pili muscles* attached to hair follicles contract in response to cold, causing goose pimples.
  - Hair on the head protects against the sun's rays and decreases heat loss; eyelashes, eyebrows, and hair in the nostrils and external ear canals block the entrance of foreign particles.

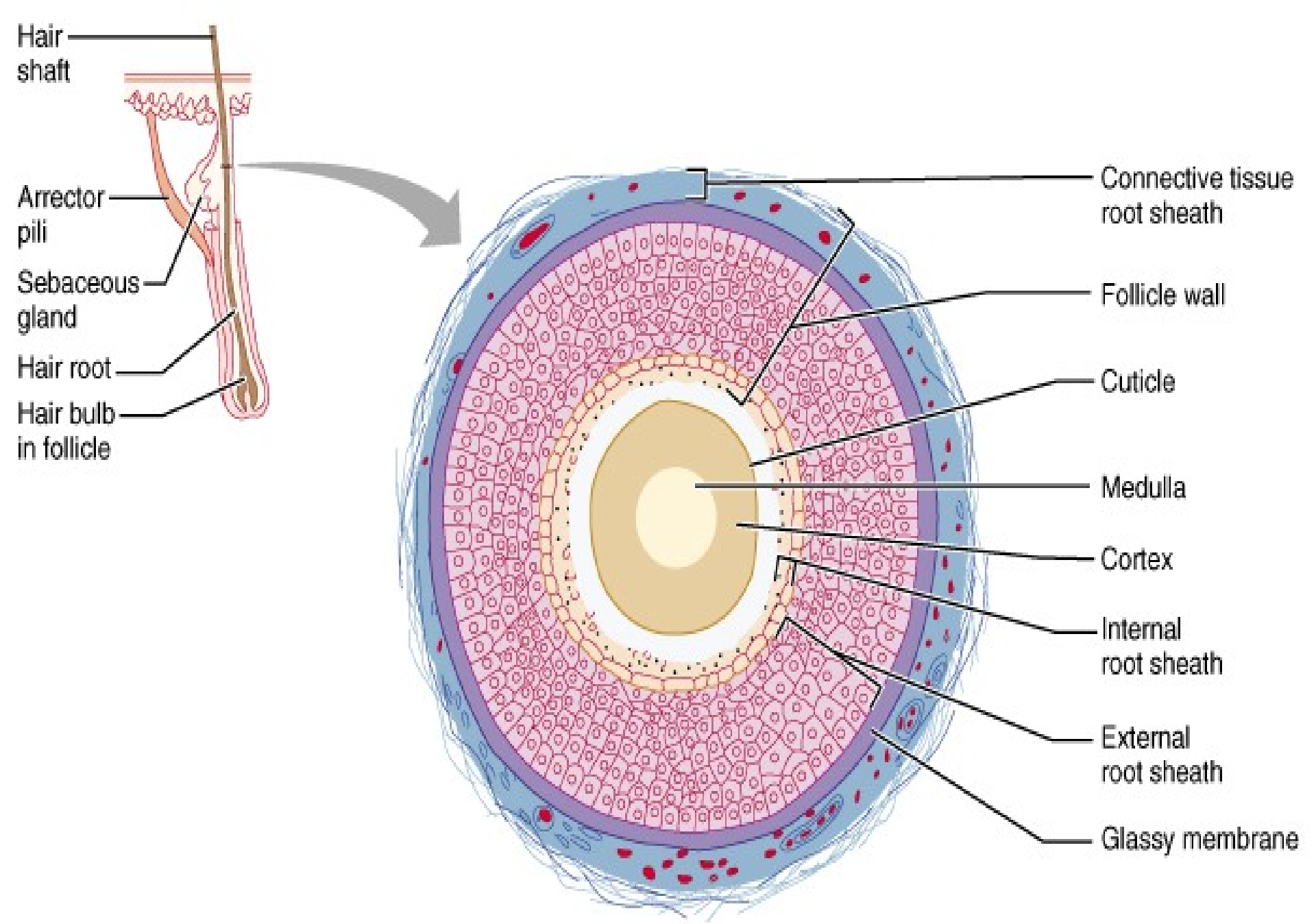

Hair Shaft
Stratum Corneum
Stratum Lucidum
Stratum Granulosum
Stratum Spinosum
Epi-
dermis
Stratum Basale
(Stratum Germinativum)
Dermal
Papilla
Sudoriferous
(sweat)
Gland
Sebaceous Gland
(oil gland)
Dermis
Arrector Pili
Muscle
Hair Follicle
Hair Root
Artery
Vein
Subcutaneous Layer

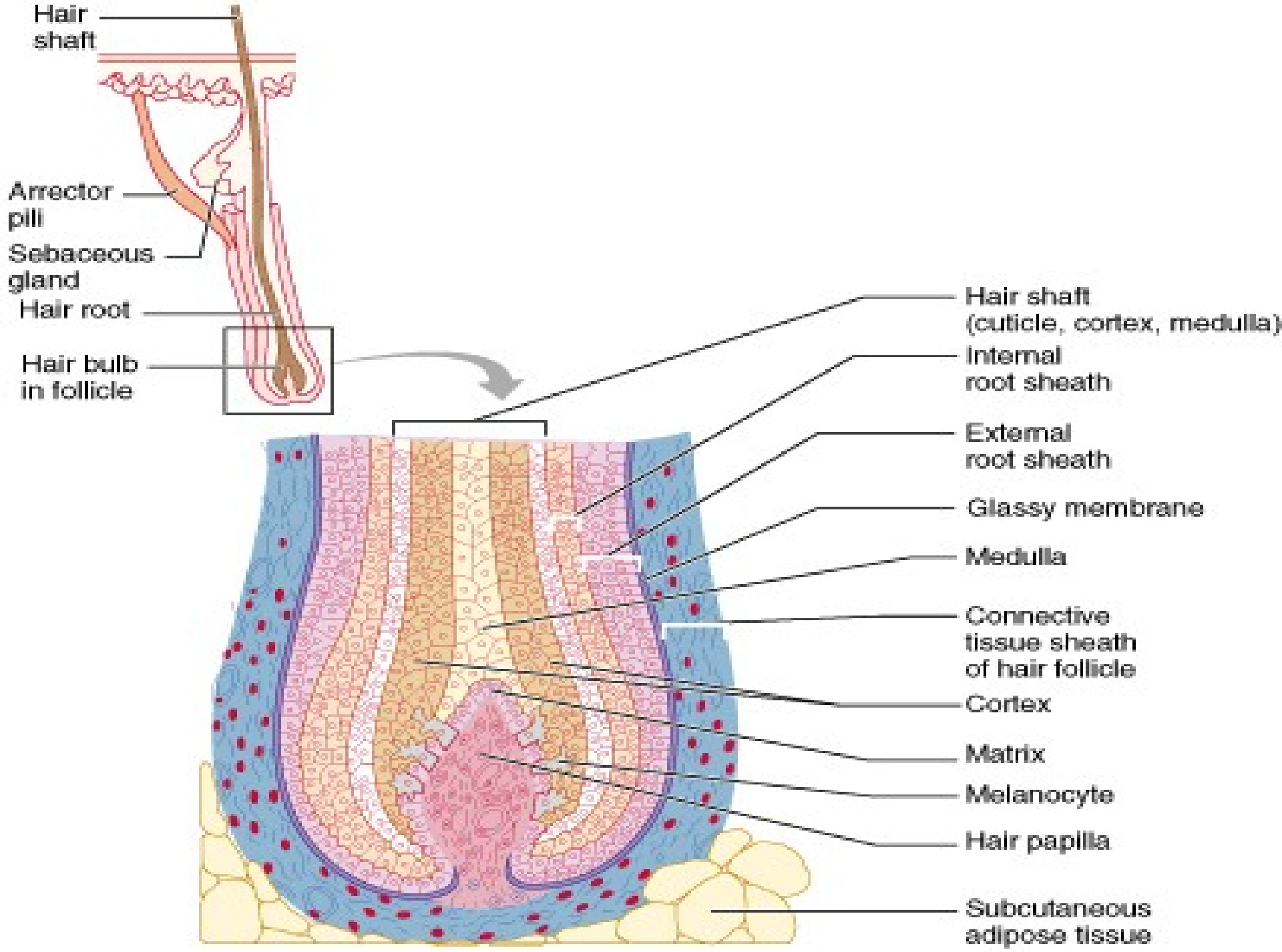


(a) Frontal section of a hair

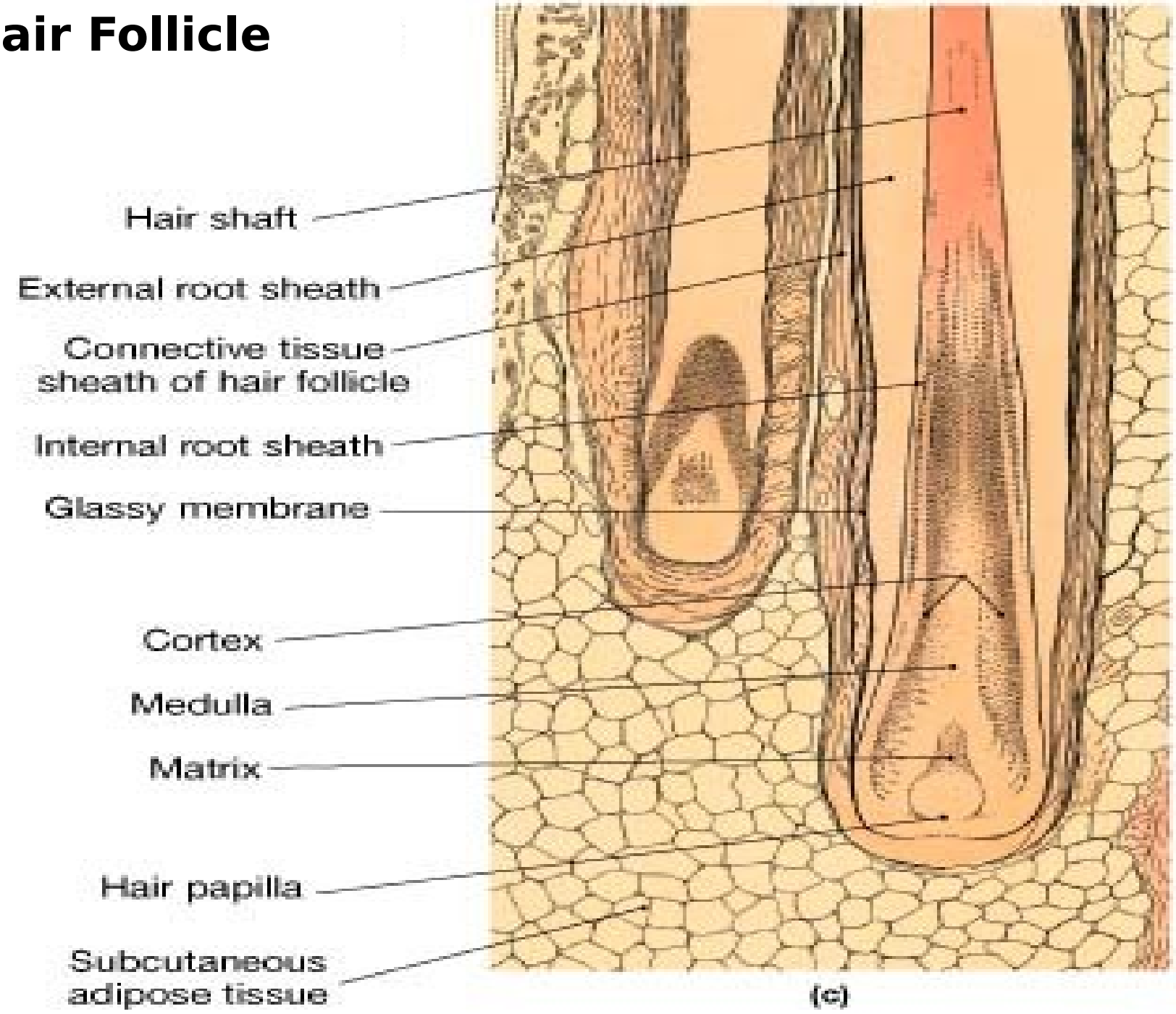


● ***FIGURE 5-7*** **Hair Follicles.** **(a)** A cross section through a hair follicle.


Hair shaft
Arrector pili
Sebaceous gland
Hair root
Hair bulb in follicle
Connective tissue root sheath
Follicle wall
Cuticle
Medulla
Cortex
Internal root sheath
External root sheath
Glassy membrane


Hair shaft
Arrector pili
Sebaceous gland
Hair root
Hair bulb in follicle
Hair shaft (cuticle, cortex, medulla)
Internal root sheath
External root sheath
Glassy membrane
Medulla
Connective tissue sheath of hair follicle
Cortex
Matrix
Melanocyte
Hair papilla
Subcutaneous adipose tissue

Hair Follicle



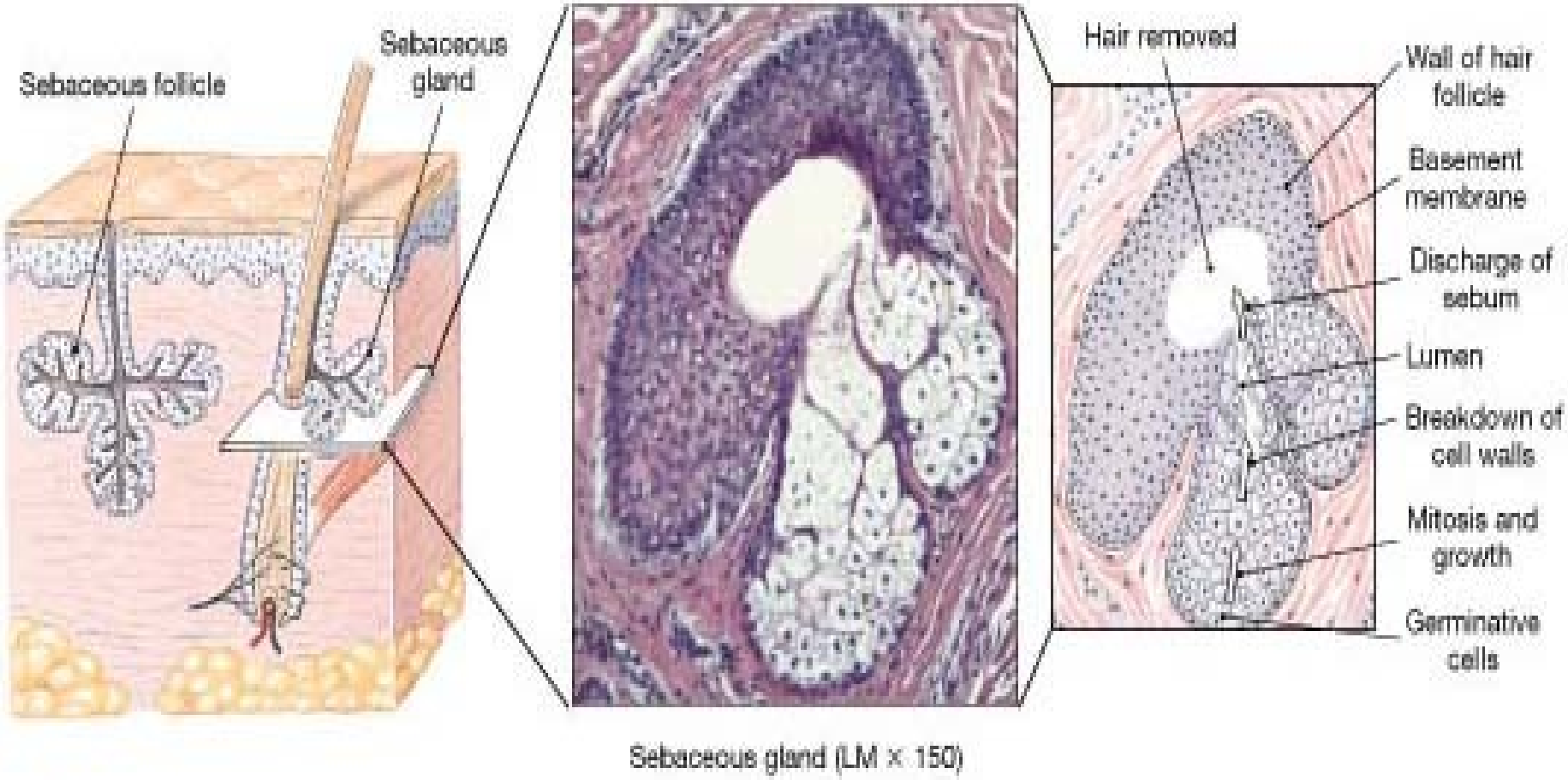
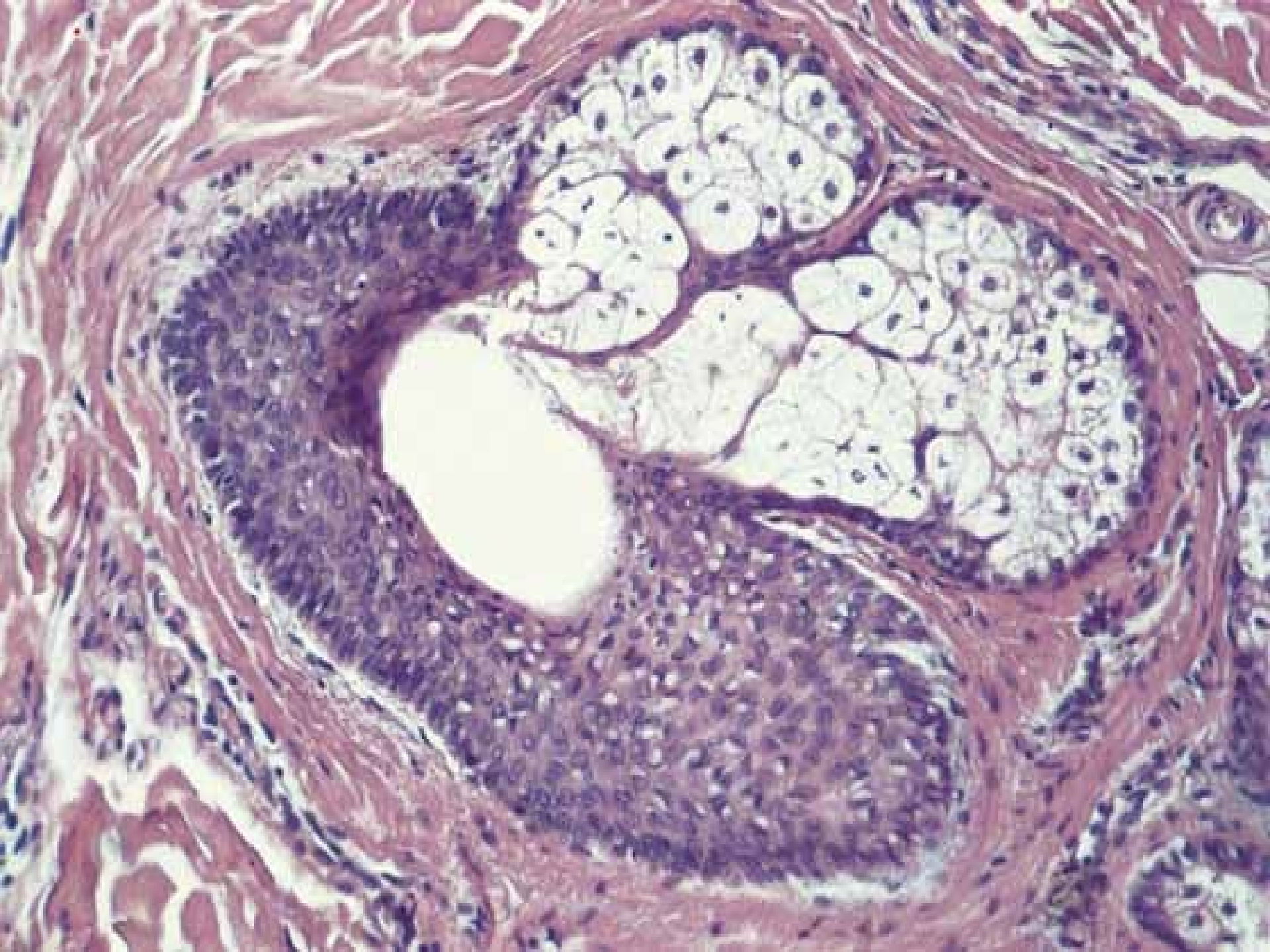


FIGURE 5-8 Sebaceous Glands and Follicles. The structure of sebaceous glands and sebaceous follicles in the skin.



NAILS

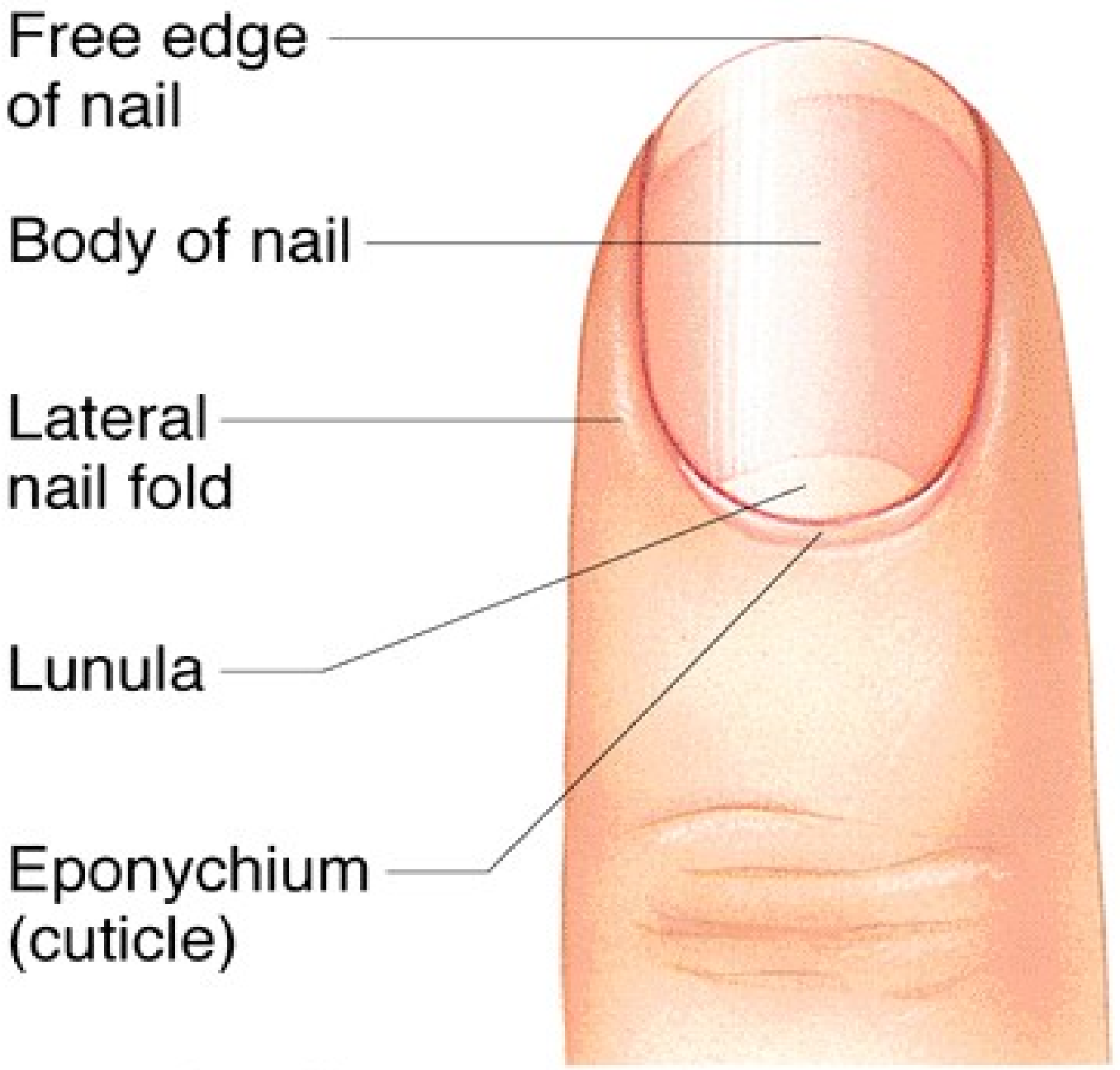
- Packed, hard, keratinized cells
- Nail matrix (root)
- Nail body
- Nail free edge

EPIDERMAL DERIVATIVES

- **Nails**
  - Nails are plates of tightly packed, hard, keratinized cells of the epidermis.
  - Each nail has three main parts:
  - (1) the *nail body is* the portion of the nail that is visible;
  - (2) the free edge *is the* part that may extend past the distal end of the digit;

EPIDERMAL DERIVATIVES

- **Nails**
  - (3) the *nail root is* the portion that is buried in a fold of skin.
  - Other nail structures include the *lunula* (whitish semilunar area) and the *eponychium* (cuticle).
  - The *nail matrix is* a region of epithelium under the nail root; growth of nails occurs by the transformation of superficial cells of the matrix into nail cells.



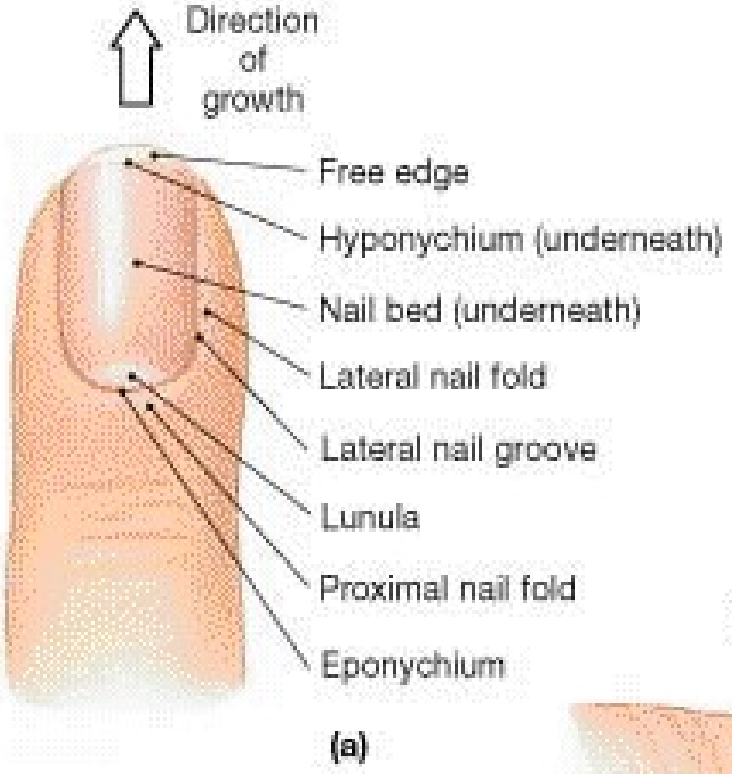
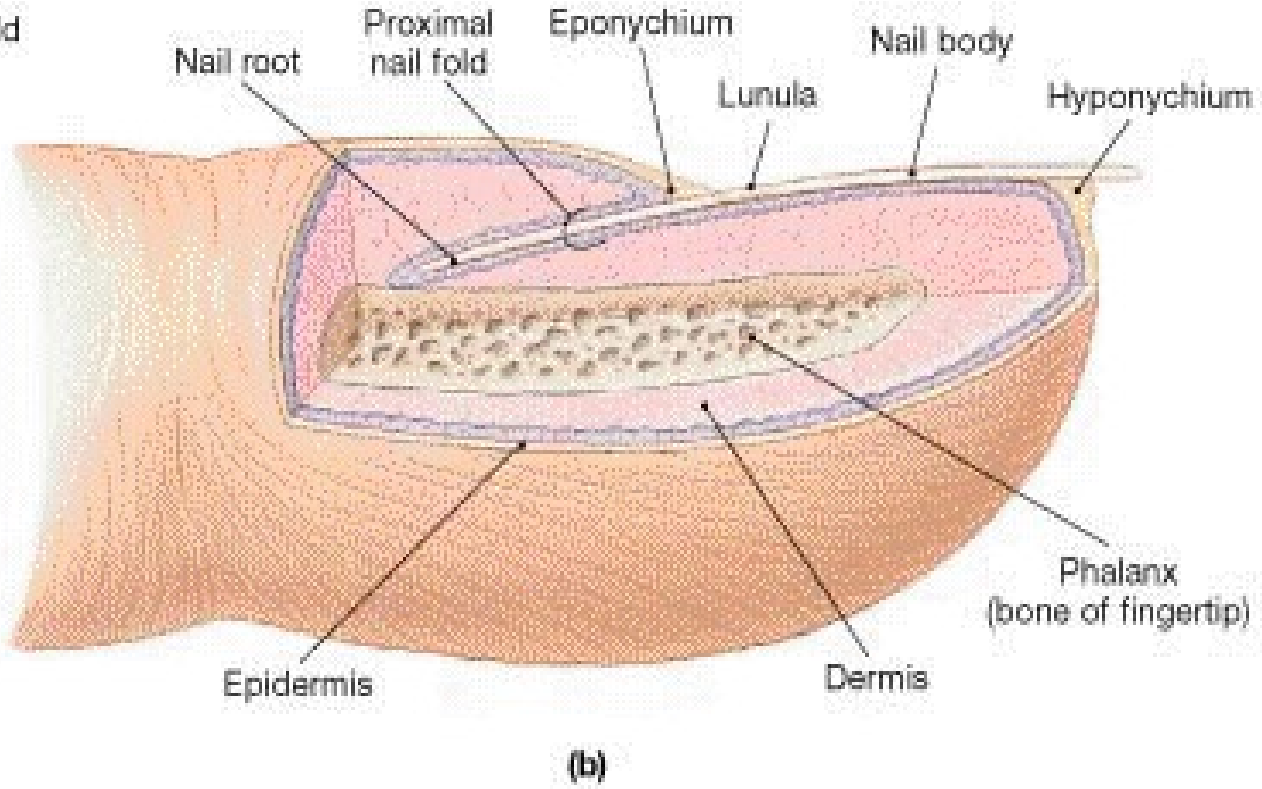


FIGURE 5-10 Structure of a Nail. The prominent features of a typical fingernail as viewed **(a)** from the surface and **(b)** in section.



LOOSE ENDS

- Skin wounds
- Healing process
- Burns

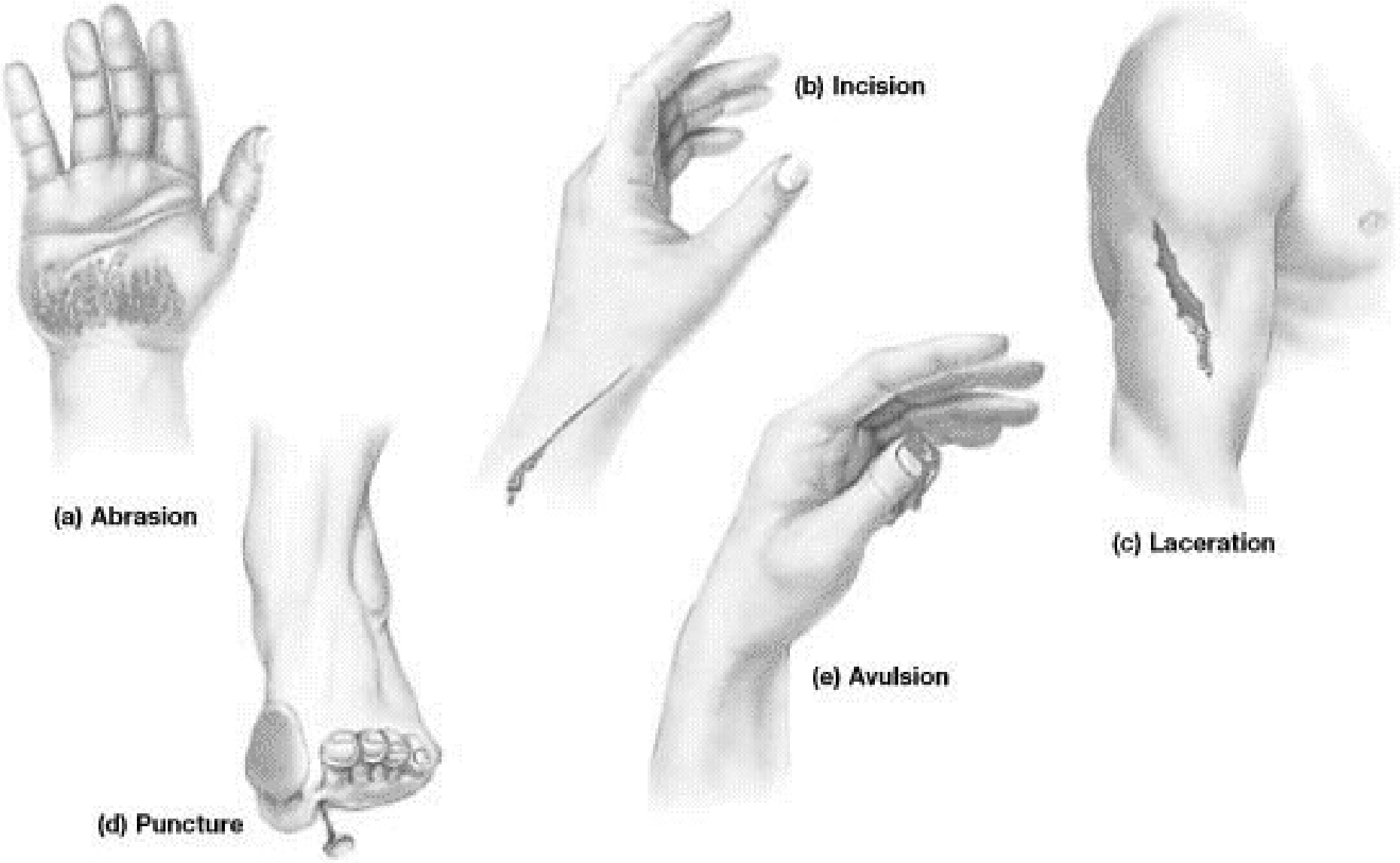
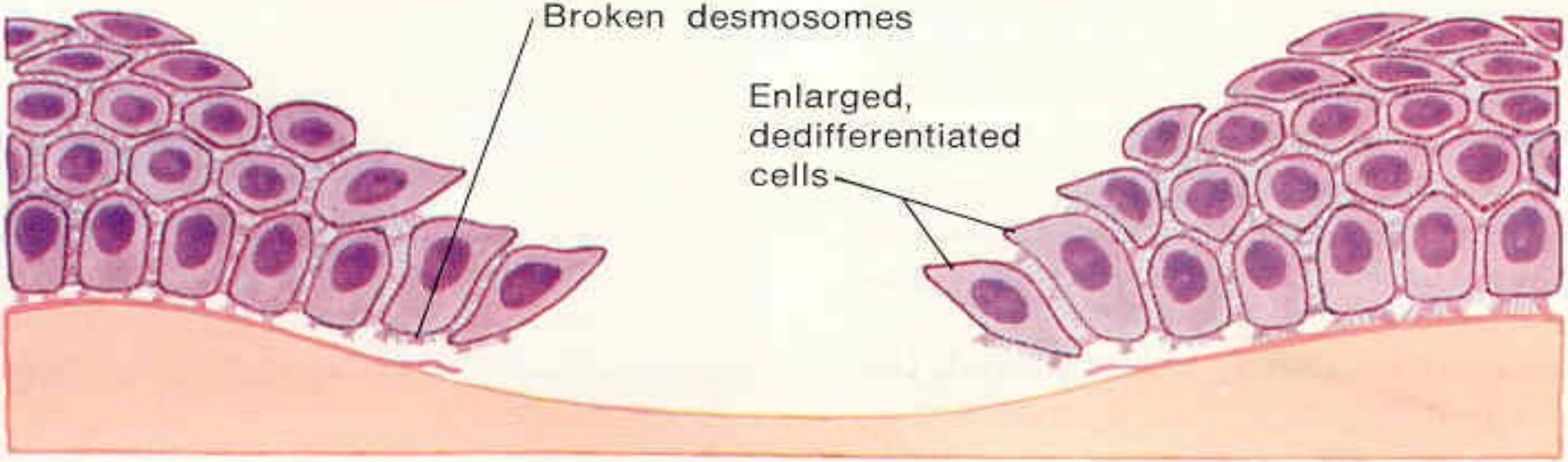
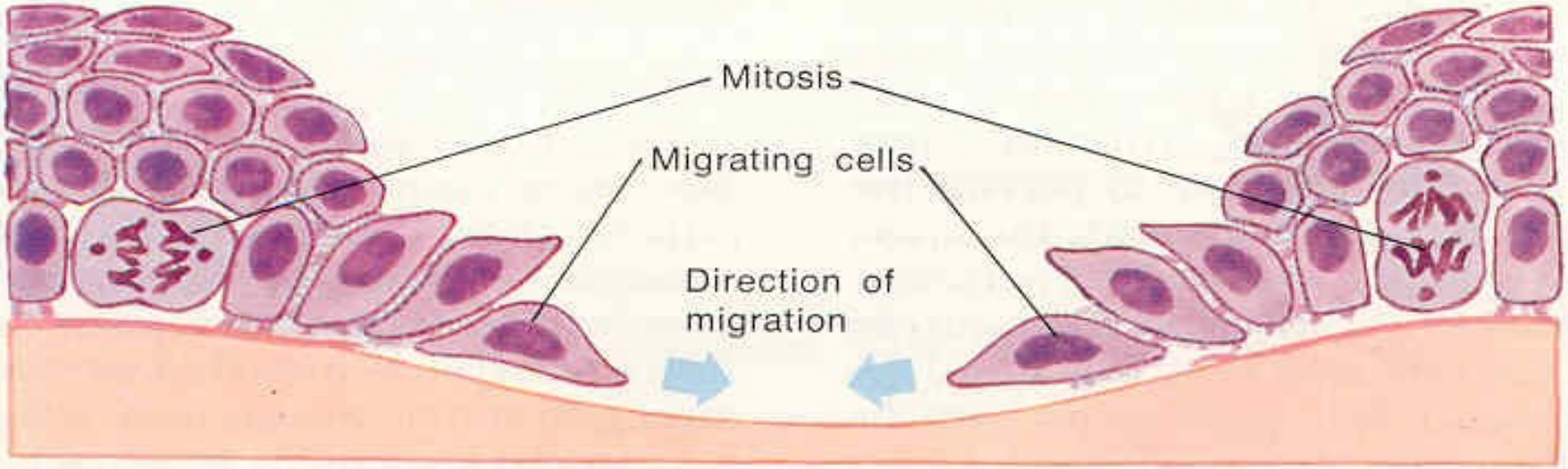


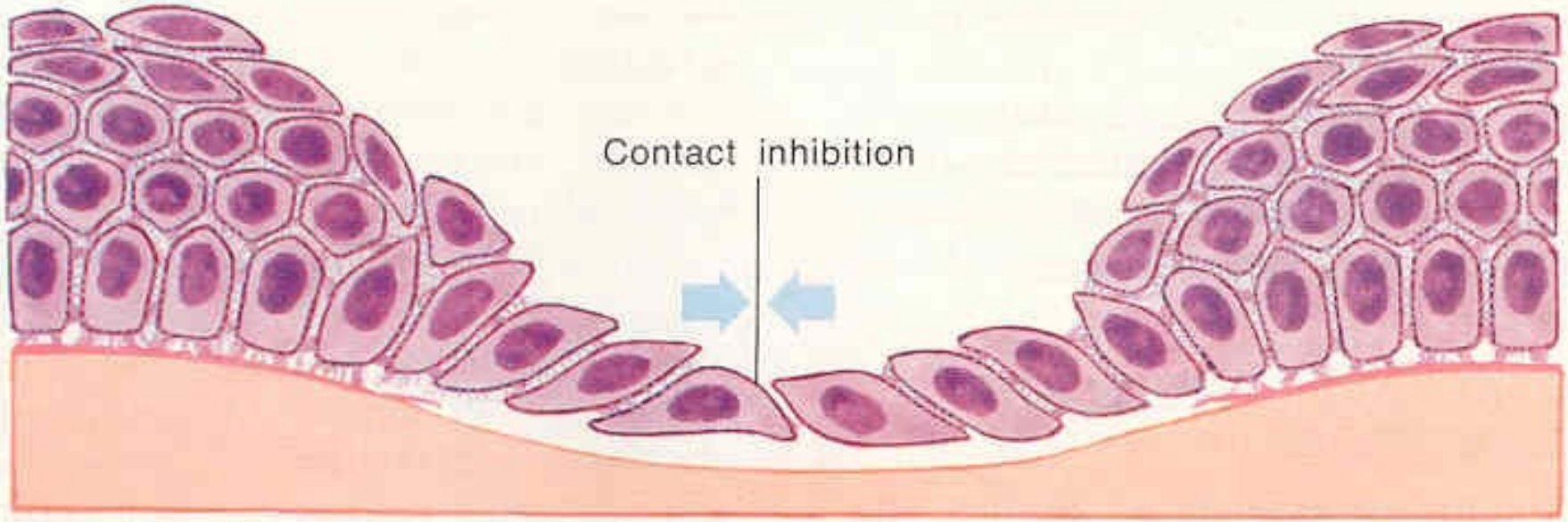
Figure A-13 Major Types of Open Wounds



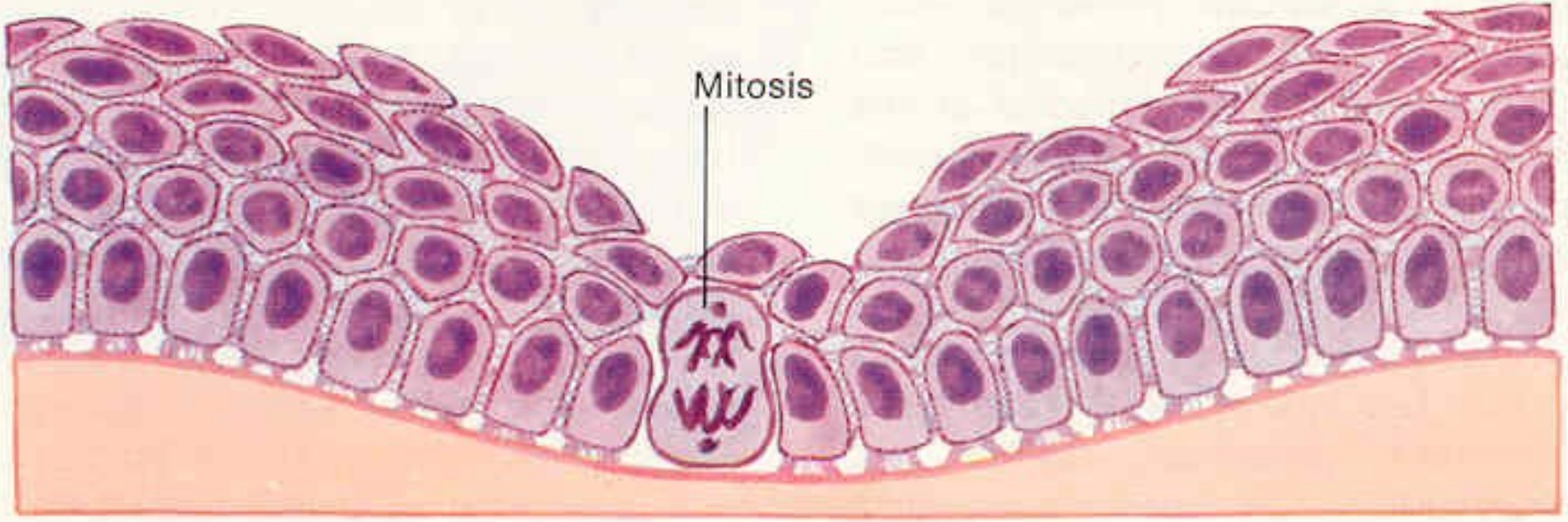
Following injury, basal cells in area next to wound break desmosomal contact with basement membrane and enlarge and dedifferentiate



Dedifferentiated basal cells migrate across wound defect while mitoses in intact epithelium provide replacements for migrated cells

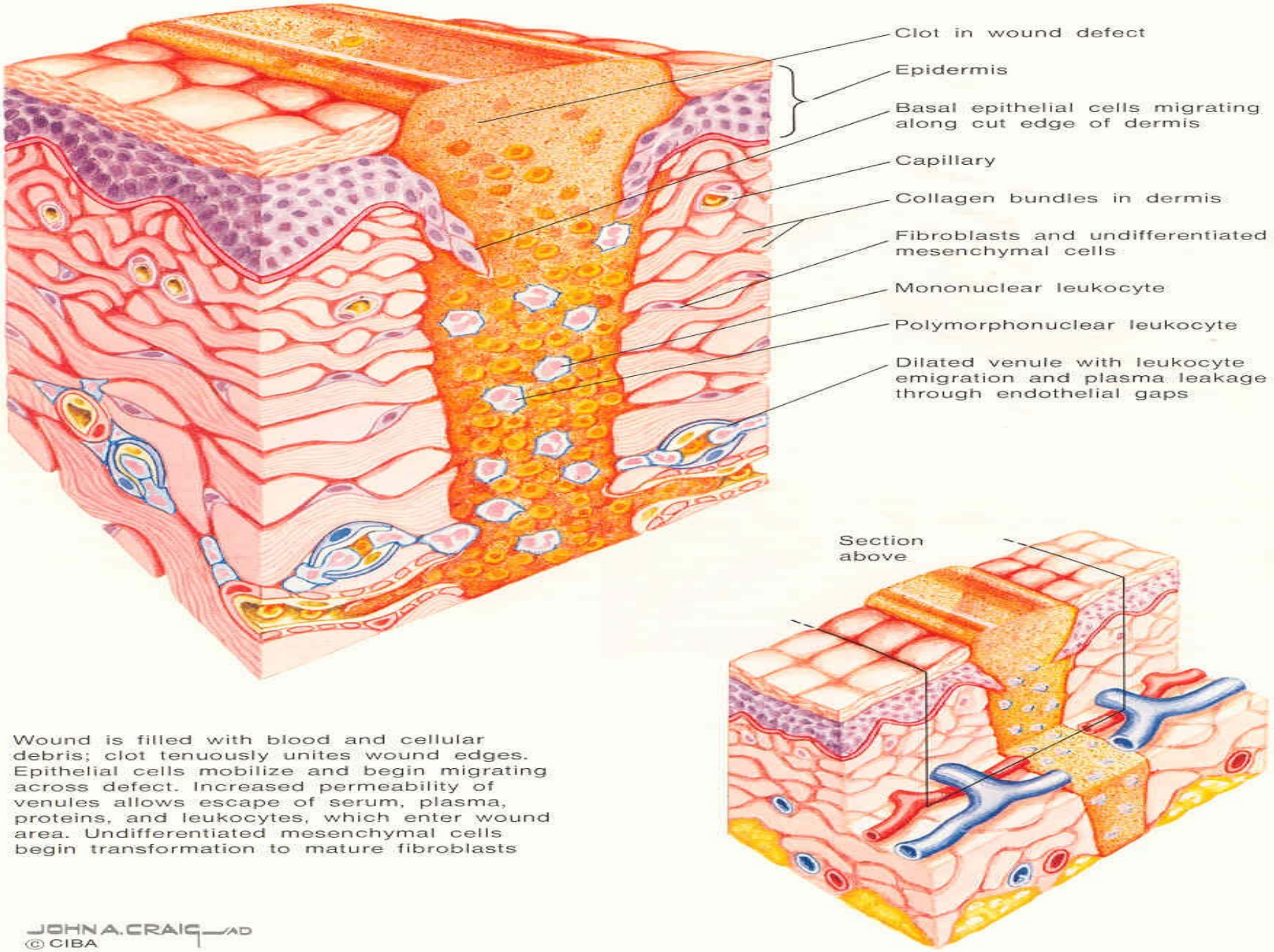


Migration continues until advancing cells from opposite sides of wound meet, causing contact inhibition of migration



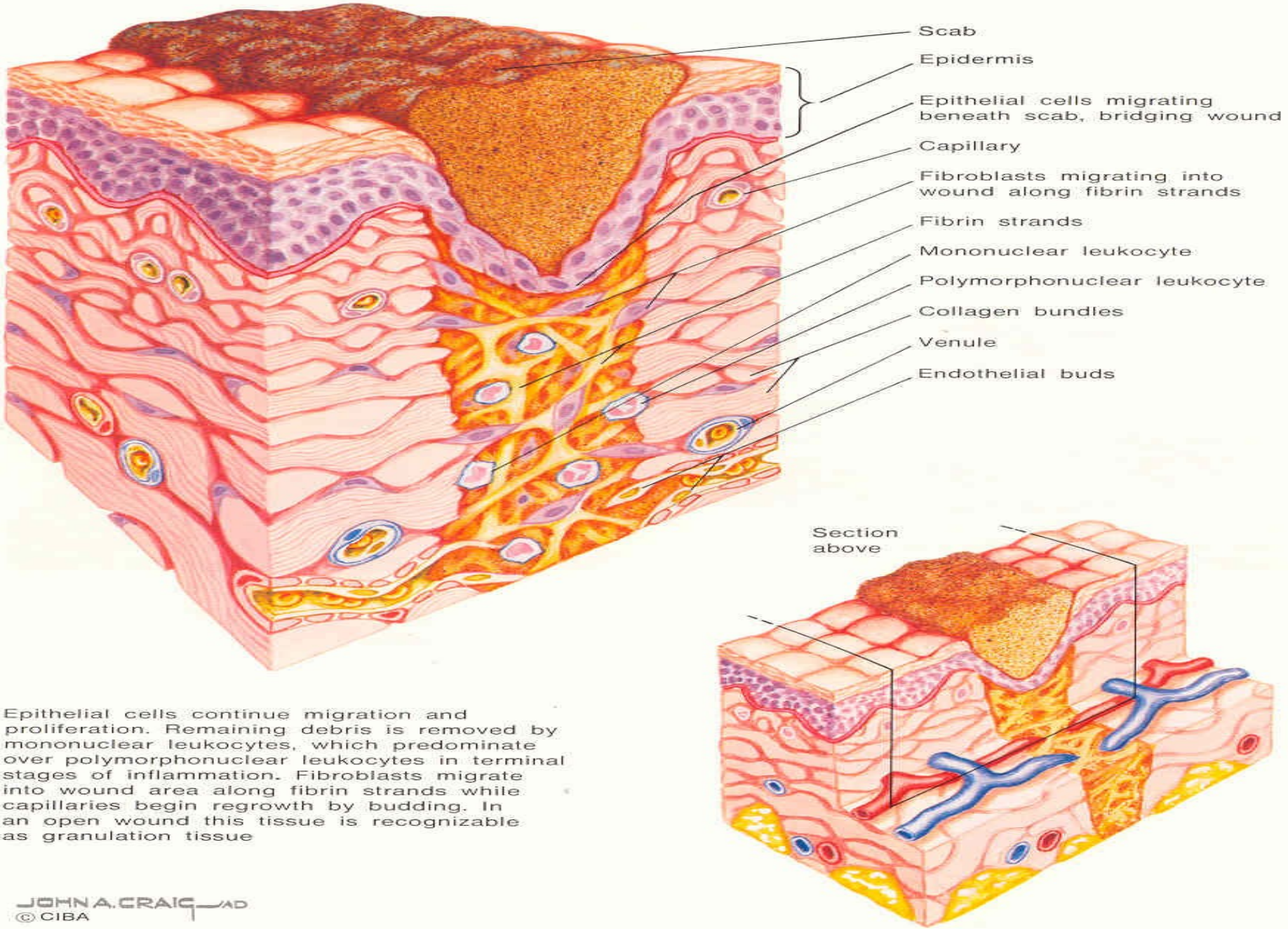
Basal cells differentiate and epithelial stratification is restored by mitosis

Skin Wound Repair (Inflammatory Phase)



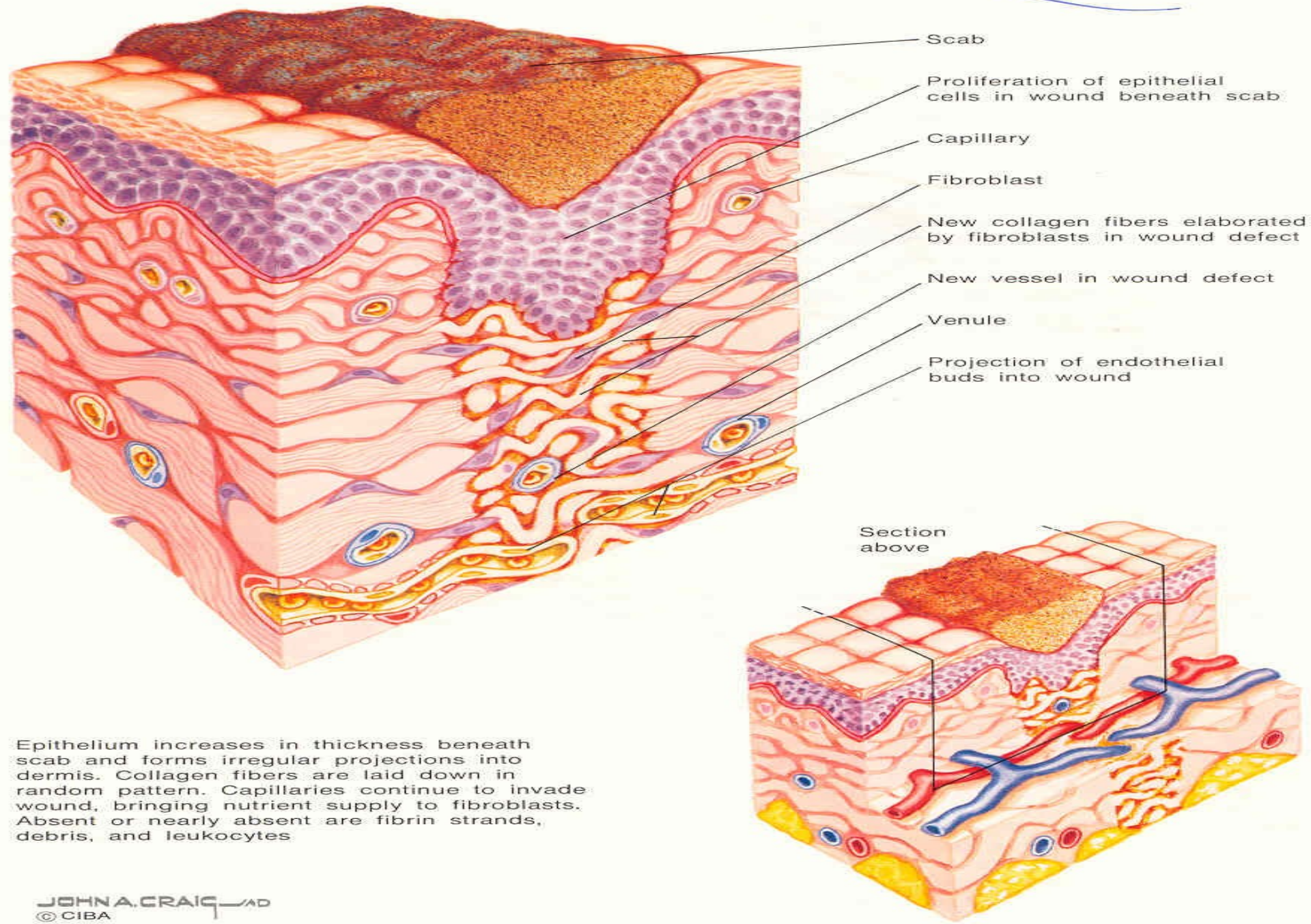
Wound is filled with blood and cellular debris; clot tenuously unites wound edges. Epithelial cells mobilize and begin migrating across defect. Increased permeability of venules allows escape of serum, plasma, proteins, and leukocytes, which enter wound area. Undifferentiated mesenchymal cells begin transformation to mature fibroblasts

Skin Wound Repair (Migratory Phase)



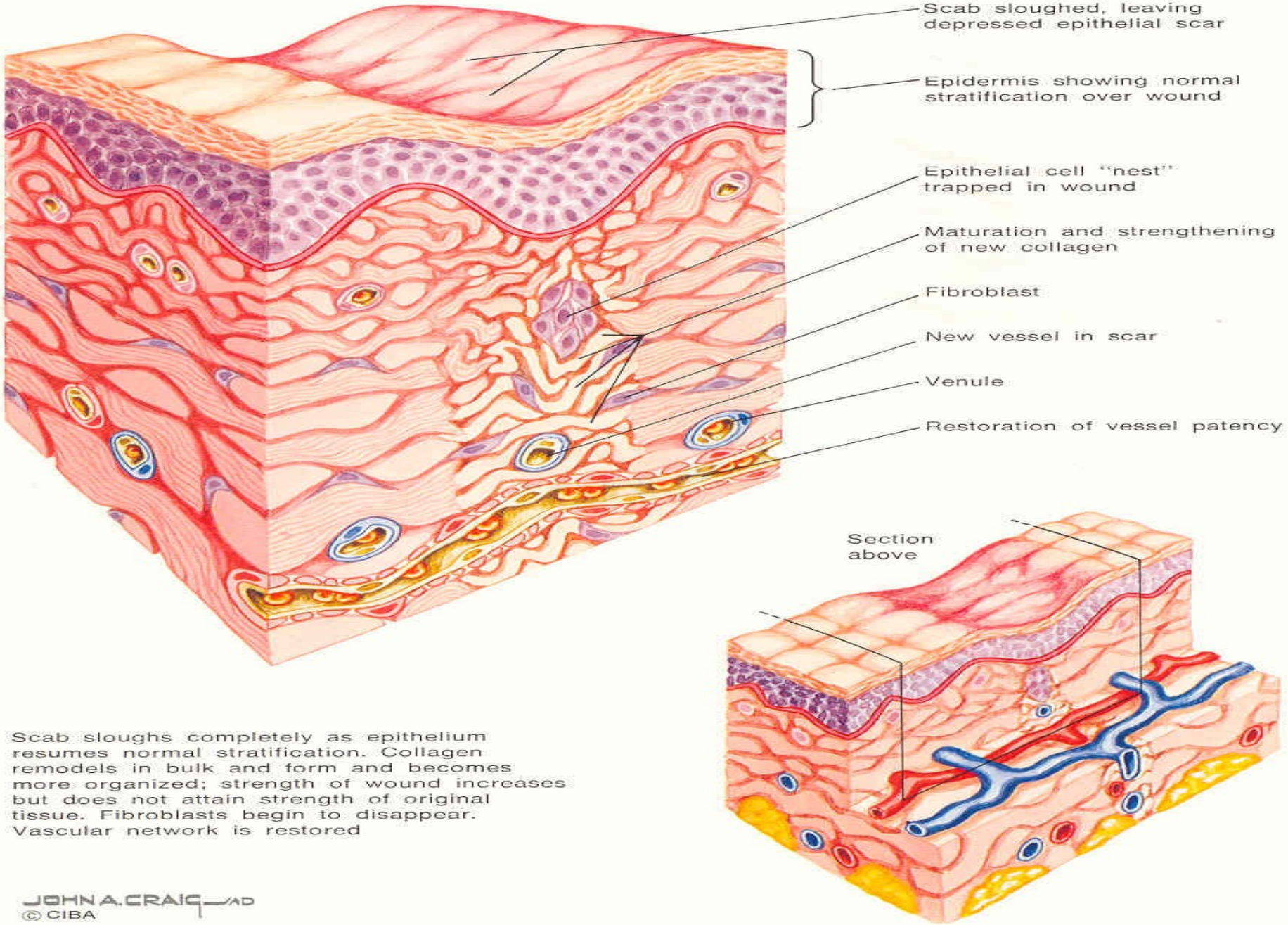
Epithelial cells continue migration and proliferation. Remaining debris is removed by mononuclear leukocytes, which predominate over polymorphonuclear leukocytes in terminal stages of inflammation. Fibroblasts migrate into wound area along fibrin strands while capillaries begin regrowth by budding. In an open wound this tissue is recognizable as granulation tissue

Skin Wound Repair (Proliferative Phase)



Epithelium increases in thickness beneath scab and forms irregular projections into dermis. Collagen fibers are laid down in random pattern. Capillaries continue to invade wound, bringing nutrient supply to fibroblasts. Absent or nearly absent are fibrin strands, debris, and leukocytes

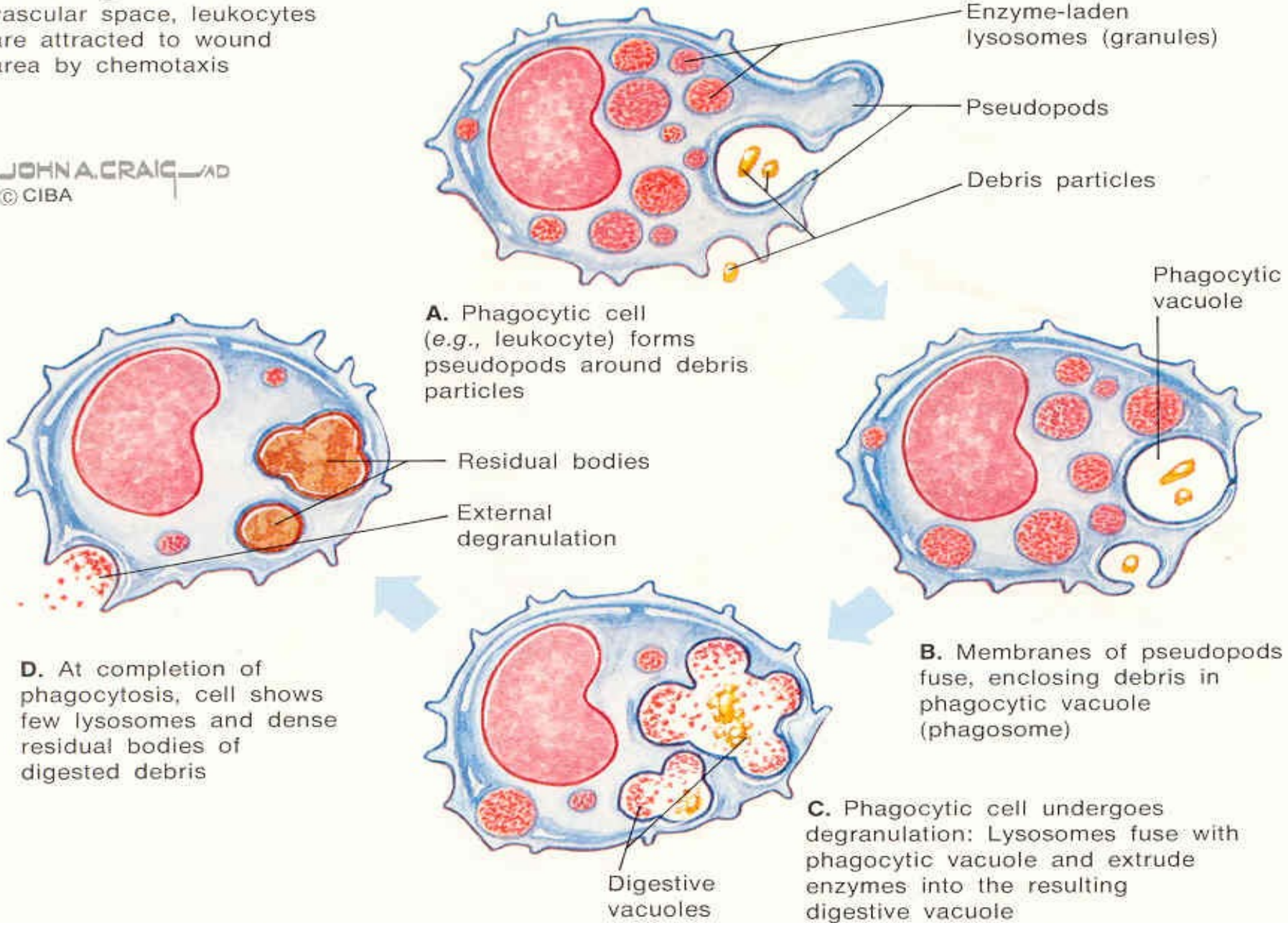
Skin Wound Repair (Maturation Phase)



Scab sloughs completely as epithelium resumes normal stratification. Collagen remodels in bulk and form and becomes more organized; strength of wound increases but does not attain strength of original tissue. Fibroblasts begin to disappear. Vascular network is restored

Phagocytosis

After emigration from vascular space, leukocytes are attracted to wound area by chemotaxis



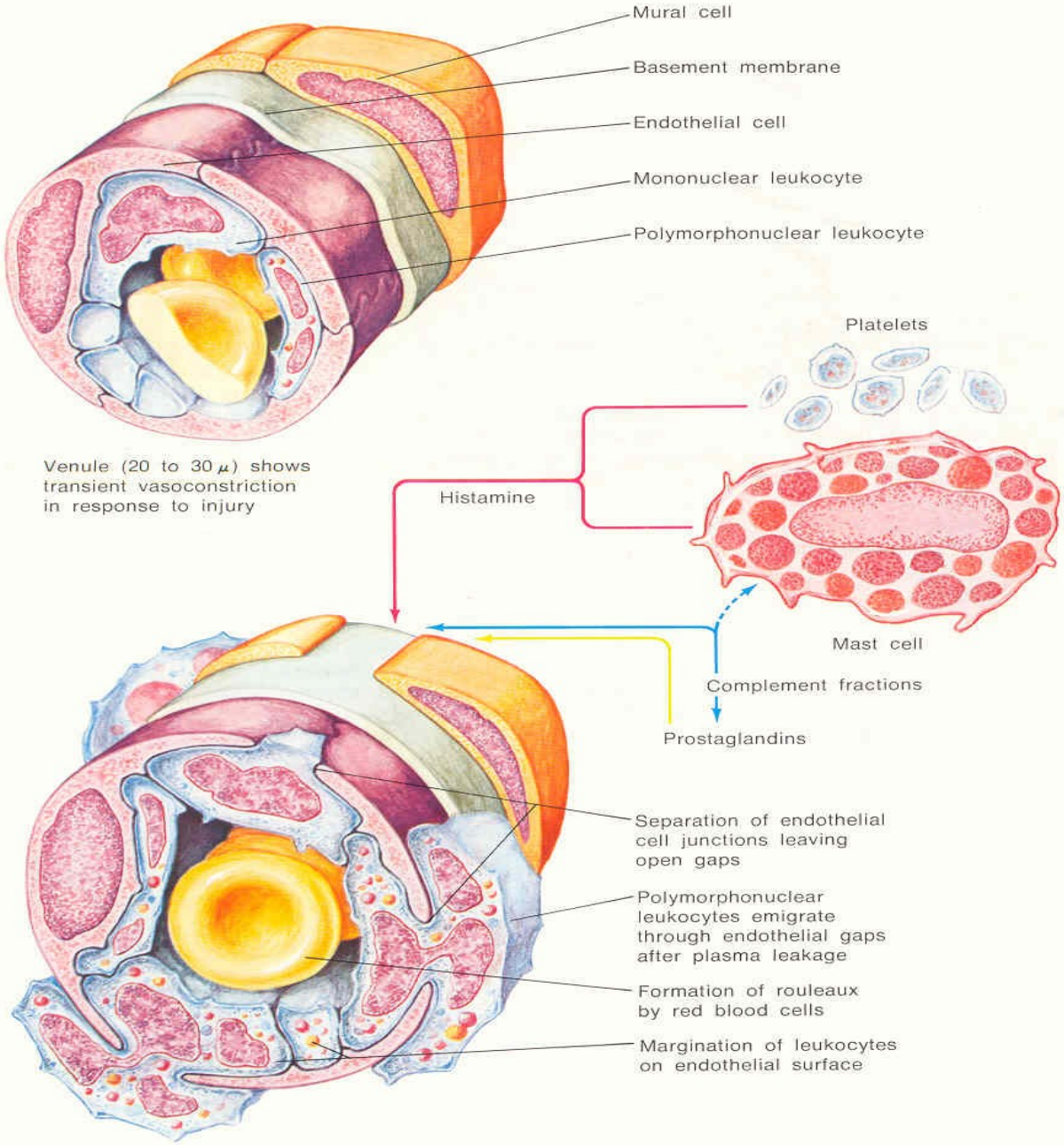
A. Phagocytic cell (*e.g.*, leukocyte) forms pseudopods around debris particles

B. Membranes of pseudopods fuse, enclosing debris in phagocytic vacuole (phagosome)

C. Phagocytic cell undergoes degranulation: Lysosomes fuse with phagocytic vacuole and extrude enzymes into the resulting digestive vacuole

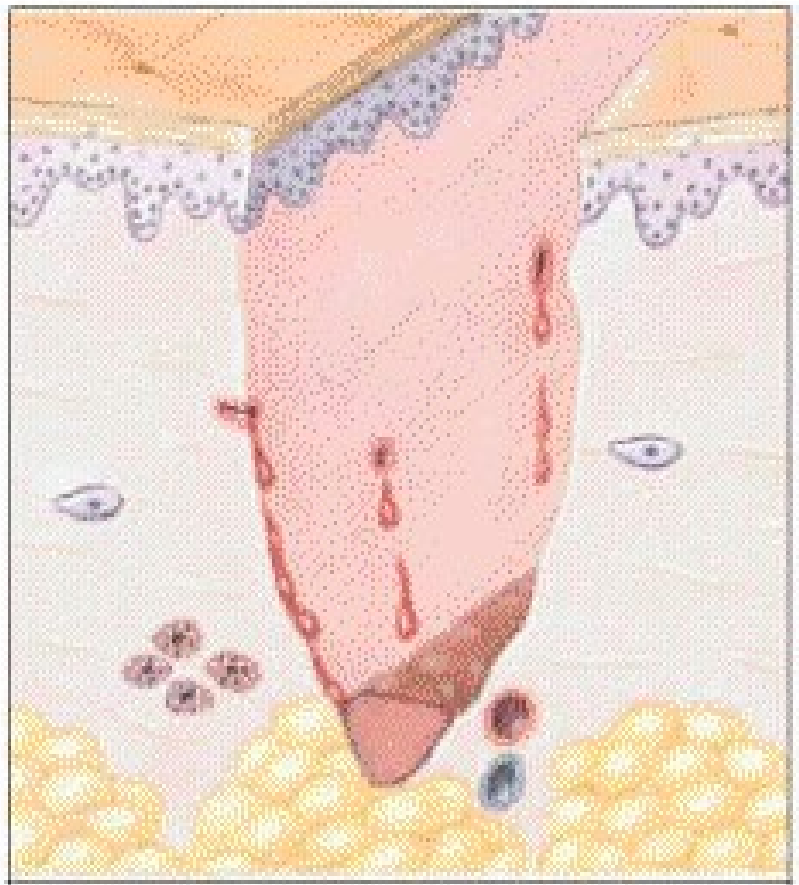
D. At completion of phagocytosis, cell shows few lysosomes and dense residual bodies of digested debris

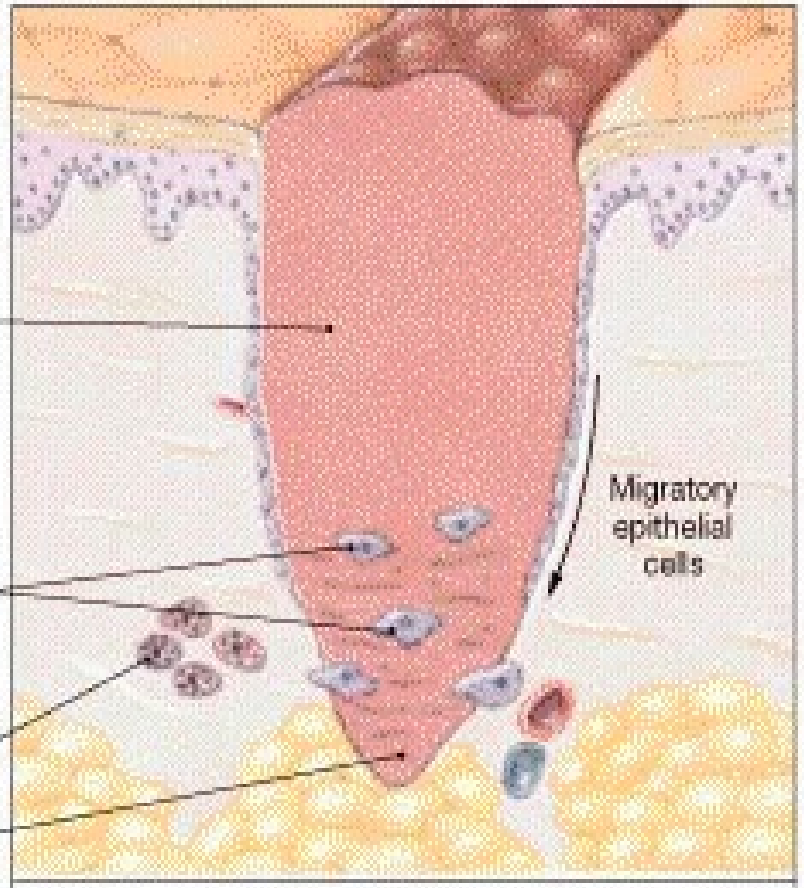
Vascular Response to Injury



Histamine and other substances cause active vasodilatation of local vessels and increased permeability at level of venules

JOHN A. CRAIG, M.D.

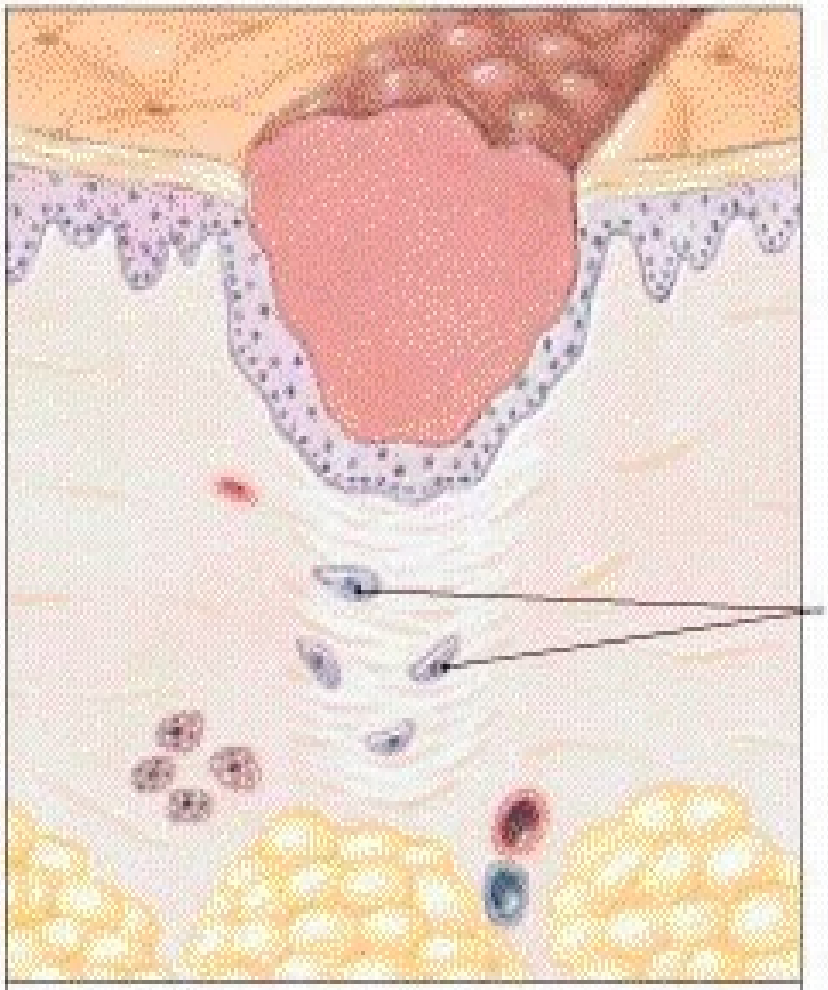




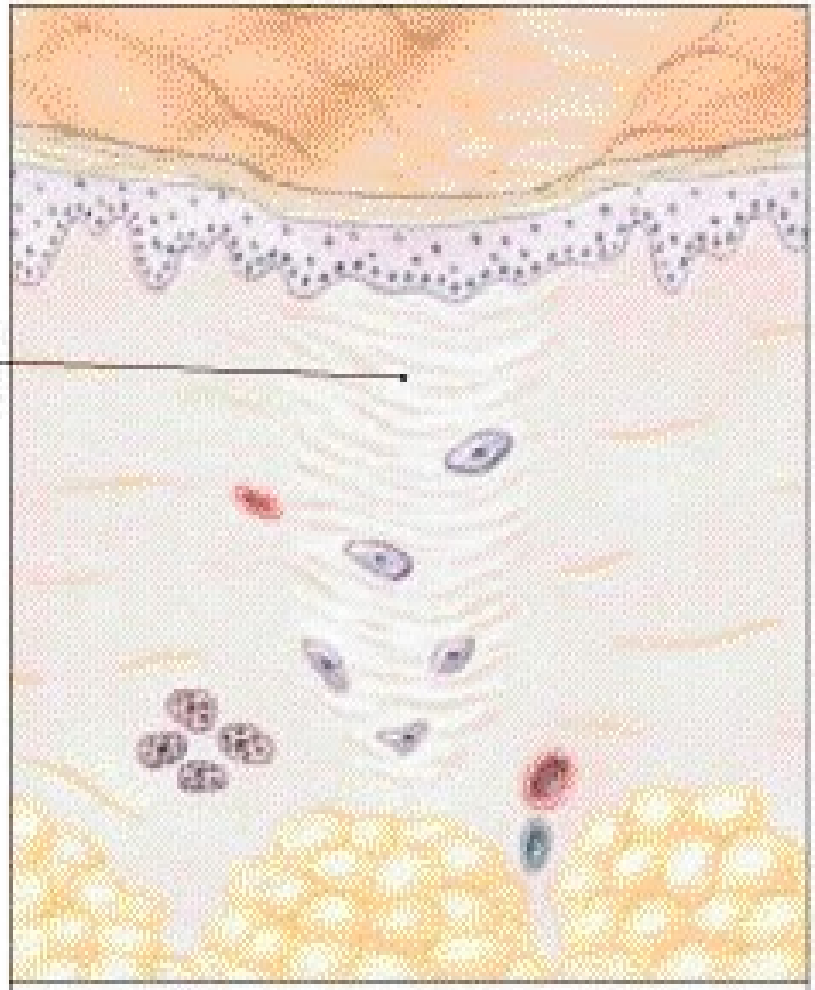
Step 1: Bleeding occurs at the injury site immediately after the injury, and mast cells in the region trigger an inflammatory response.

Step 2: After several hours, a scab has formed and cells of the stratum germinativum are migrating along the edges of the wound. Phagocytic cells are removing debris, and more of these cells are arriving via the enhanced circulation. Clotting around the edges of the affected area partially isolates the region.

FIGURE 5-11 Integumentary Repair

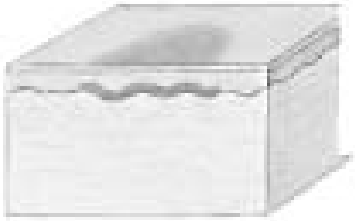


Step 3: One week after the injury, the scab has been undermined by epidermal cells migrating over the meshwork produced by fibroblast activity. Phagocytic activity around the site has almost ended, and the fibrin clot is disintegrating.

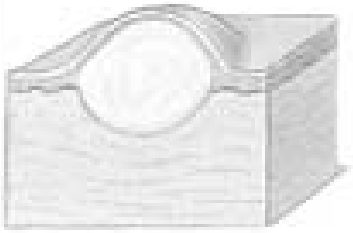


Step 4: After several weeks, the scab has been shed, and the epidermis is complete. A shallow depression marks the injury site, but fibroblasts in the dermis continue to create scar tissue that will gradually elevate the overlying epidermis.

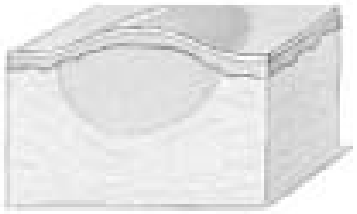
FIGURE 5-11 Integumentary Repair



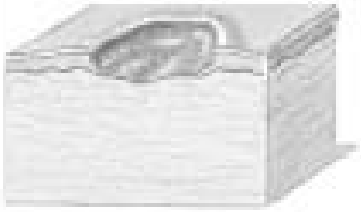
A flat **macule** is a localized change in skin color. Example: freckles



A **pustule** is a papule-sized lesion filled with pus. Example: acne pimple

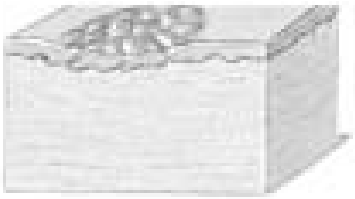


Accumulation of fluid in the papillary dermis may produce a **wheal**, a localized elevation of the overlying epidermis. Example: hives

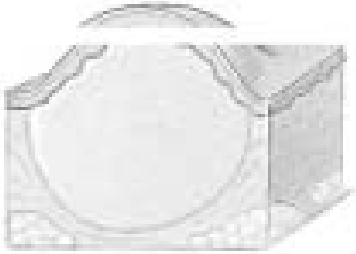


An **erosion**, or ulcer, may occur following the rupture of a vesicle or pustule. Eroded sites have lost part or all of the normal epidermis. Example: decubitis ulcer

A **papule** is a solid elevated area containing epidermal and papillary dermal components. Example: mosquito or other insect bite



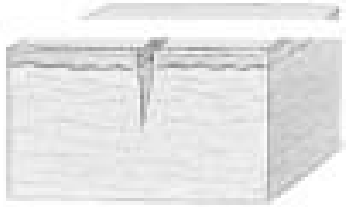
A **crust** is an accumulation of dried sebum, blood, or interstitial fluid over the surface of the epidermis. Example: seborrheic dermatitis, scabs, impetigo.



Nodules are large papules that may extend into the subcutaneous layer. Example: cyst

Scales form as a result of abnormal keratinization. They are thin plates of cornified cells. Example: psoriasis

A **vesicle**, or blister, is a papule with a fluid core. A large vesicle may be called a bulla. Example: second-degree burn



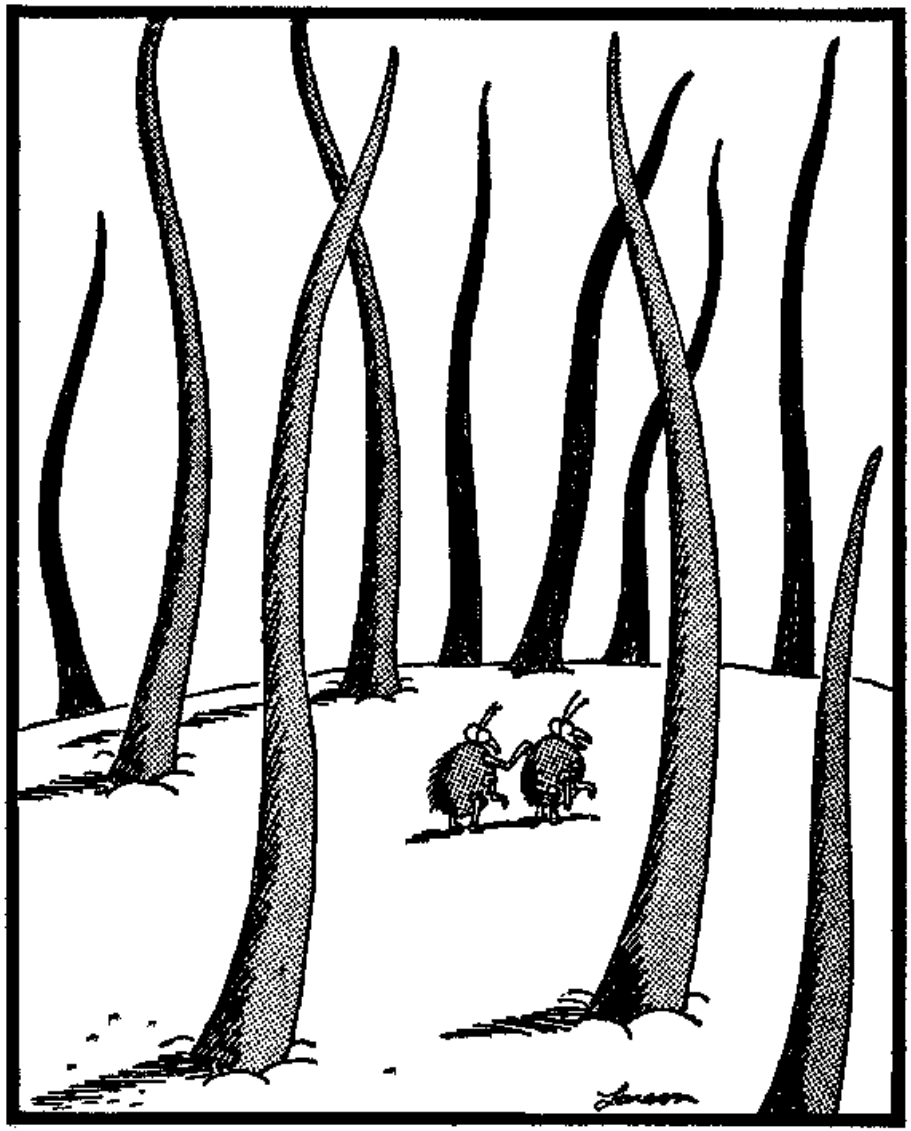
A **fissure** is a split in the integument that extends through the epidermis and into the dermis. Example: athlete's foot

Figure A-11 Skin Signs

BURNS

- **1ST Degree Burn** = only the epidermis is destroyed.
- **2nd Degree Burn** = the epidermis and part of the dermis are involved and blistering occurs.
- **3rd Degree Burn** = the epidermis and dermis (and often part of the hypodermis) are destroyed.

QUESTIONS



"Yes! Yes! That's it! ... Just a little higher."